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Economic Impact Analysis for the Lime Manufacturing MACT Standard

Draft Report

Prepared for

Eric L. Crump
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Innovative Strategies and Economics Group
Research Triangle Park, NC 27711

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Research Triangle Park, NC 27711

Prepared by

Robert H. Beach
Brooks M. Depro
Jui-Chen Yang
RTI
Health, Social, and Economics Research
Research Triangle Park, NC 27709

CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

In the Clean Air Act (CAA), Congress gave the U.S. Environmental Protection Agency (EPA) broad authority to protect air resources throughout the nation. Under Section 112 of the CAA, EPA is developing a National Emission Standard for Hazardous Air Pollutants (NESHAP) designed to reduce emissions generated in the production of lime. Lime is primarily used by chemical and industrial users, with the largest consumption among that group occurring in the steel industry. Other important categories of lime use include environmental applications, construction, and agriculture. Lime production leads to emissions of particulate matter (PM), including metals; hydrochloric acid (HCl); and gaseous pollutants, including carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x). The proposed rule is primarily intended to reduce the emissions of PM/metals from lime kilns. This report evaluates the economic impacts resulting from the proposed rules.

ES.1 Industry Profile

The production of lime begins with the quarrying and crushing of limestone. The crushed limestone is then converted into lime by heating the limestone in a kiln, a process known as calcination. When limestone is subjected to high temperatures, it undergoes a chemical decomposition resulting in the formation of lime (CaO) and the emission of CO_2. Because calcination is a reversible chemical reaction, the CO_2 emitted as a result of the process must be removed to prevent recarbonation.

Lime as it exits the kiln is known as quicklime. It can be either high calcium or dolomitic, depending on the type of limestone that was calcined. After the quicklime leaves the kiln, it is screened to remove undersized particles. Quicklime can be converted into hydrated lime. The process of hydration, also known as slaking, is a chemical reaction between lime and water. Hydrated lime is produced in a vessel called a hydrator, where a precise amount of water is slowly added to crushed or ground quicklime and the mixture is stirred and agitated. The hydrated lime may undergo further refining or proceed directly to bagging, shipment, and/or storage. The gas resulting from the hydration process contains steam and lime particles. This gas may be vented back into the kiln or sent to a control device where it is cleaned and then released (EPA, 1996).

Dead-burned dolomite, also called refractory lime, is a sintered or double-burned form of dolomitic lime. It is used for lining open hearth or electric arc steel furnaces or as an input in the refractory bricks that line basic oxygen steel furnaces. Dead-burned dolomite represented less than 2 percent of total U.S. lime production in 1999 (Miller, 1999a).

Lime producers can be broadly characterized as captive and commercial. Captive lime producers produce lime that is used by other operations within the same company, frequently at the same plant location. The markets associated with captive lime production are those for the products the lime is used to produce (e.g., steel, beet sugar). While an important input, the cost of lime is small enough relative to the total cost of production of the final goods (lime costs generally represent less than 5 percent of the value of shipments of beet sugar or iron and steel) that changes in the cost of lime production resulting from this regulation are not likely to have a significant influence on the markets for those products.

In 1999, production of lime occurred at approximately 257 kilns (EPA, 2000) located at the 108 plants across the United States that were involved in lime production. However, 11 of these plants are identified by the U.S. Geological Survey (USGS) as hydrating plants only (DOI, 2000), which, by definition, do not have any kilns. This implies that the average number of kilns for the 97 plants that have kilns is approximately 2.6 kilns per plant. During 1999, the United States produced 19.6 million metric tons of lime, with quicklime accounting for 87.2 percent of all lime production and hydrated lime accounting for 11.3 percent of lime production. The remaining 1.5 percent of lime production was dead-burned dolomite. The total value of domestic lime shipments in 1999 was $1.2 billion, for an average value of $60.10 per metric ton.

Because limestone is plentiful in the United States, and transportation for such a heavy, bulky commodity is expensive, imports make up only a small portion of total consumption of lime. In 1999, only 0.2 million metric tons were imported, accounting for 0.8 percent of total U.S. lime consumption. Most imported lime is from Canada and Mexico; small amounts are imported from other countries. Similarly, lime exports consist of a small percentage of total production. Approximately 0.3 percent of lime produced was exported in 1999. Most exported lime goes to Canada, and small amounts are exported to Jamaica and Mexico.

ES.2 Regulatory Control Costs

EPA's engineering analysis has determined the technology basis for the national emission standards on major sources of air pollution. Sources of HAP emissions in lime production include the lime kiln, the lime cooler, and materials handling operations (MHO). Model plants were developed to evaluate the effects of controls on emissions from these sources on the lime production industry. The proposed MACT standards will affect all existing major sources within the industry.[1] Costs were estimated both with and without a requirement of PM continuous emission monitoring systems (CEMS) for existing lime manufacturers. Area sources will incur costs only to perform tests to verify their status as area sources under both scenarios. The total cost of this regulation was estimated to be \$22.2 million without PM CEMS and \$23.3 million for an option requiring PM CEMS in the absence of market adjustments.[2]

In regard to the applicability of controls for a particular kiln, the engineering analysis has estimated the proportion of major sources to which each type of control costs (e.g., kiln PM controls) would apply based on the method of pollution control that the source currently uses (e.g., fabric filter, wet scrubber, electrostatic precipitator, no control). However, because of the uncertainty in determining the actual kilns that will be major sources and in determining which controls those plants will need to install, the economic analysis randomly determines the applicability of the controls and associated costs to each kiln.[3] Thus, multiple simulations of the economic impact model were performed to provide an estimate of the expected national-level impacts based on the engineering estimates of the proportions of major sources currently using each type of pollution control device that will incur costs and the amount of those costs.

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[1]The proposed controls and associated costs for new sources under the proposed regulation are presented in Section 3 of this report. However, EPA does not anticipate any differential impact on these sources. Thus, the economic impact analysis described in Section 4 focuses on the regulatory effects on existing sources only.

[2]This option requires PM CEMS instead of bag leak defectors (BLD) for kilns with single-stack control devices. Kilns with multi-stack PM control devices will not be required to use PM CEMS. The costs of PM CEMS include the capital costs of the system and the cost of feed rate monitoring.

[3]For small companies, the engineers gathered more information so that specific kiln-level costs were assigned to kilns owned by small companies rather than randomly assigning costs to these kilns. This was done to facilitate the small business analysis. However, there were insufficient resources to assign kiln-specific costs to all kilns.

ES.3 Economic Impact Analysis

The proposed NESHAP to control HAPs from lime kilns will directly (through imposition of control costs) and indirectly (through changes in market prices) affect each of the commercial lime kilns operating in the lime production industry. In addition, a subset of the captive lime kilns will be directly affected. This NESHAP does not apply to lime kilns used captively in the production of beet sugar or pulp and paper, but captive lime plants operating in other industries will incur compliance costs. Implementation of the proposed regulations will increase the costs of producing lime. The compliance costs will vary across kilns depending on their physical characteristics and existing level of control. The response to these additional costs will determine the economic impacts of the regulation. Specifically, the costs of the regulations may induce some owners to change their current operating rates or even to close down. These choices affect, and are in turn are affected by, the market price for lime.

Because of the low value and high transport cost of lime, most lime is consumed within 300 miles of where it is produced (Miller, 2000a), although access to river transport allows a firm to expand its market beyond that radius. Thus, each lime plant may consider the market for its commodity to be regional. Because many of the markets for individual lime plants overlap, discrete regional markets are not clearly defined, but regional markets could potentially be defined and the model applied at that level. However, data limitations preclude estimation of a regional model. To estimate a model of this type, EPA would ideally have information on the quantities of quicklime and hydrated lime produced for commercial sale at each lime facility as well as regional market prices for each region. However, there is no publically available data distinguishing lime produced for commercial and captive use at the state or regional level, and even data on total lime production are often not available at the state or regional level because states with small levels of production are aggregated or not reported to avoid disclosing individual company information. Thus, the market for lime was modeled as a national perfectly competitive market. The perfectly competitive market structure reflects the assumption that individual facilities have negligible power over the market price of the products and thus take the prices as "given" by the market.

Table ES-1 summarizes the national-level economic impact results for a baseline year of 1997, which reflect the mean impact measures resulting from the model simulations. As shown, imposing the proposed regulation results in a price increase of roughly 2.1 percent

Table ES-1. National-Level Market Impacts of the Proposed Lime Manufacturing MACT: 1997

		Without PM CEMS		With PM CEMS	
		Change		Change	
	Baseline	Absolute	Relative	Absolute	Relative
Price ($/metric ton)	$56.60	$1.17	2.1%	$1.20	2.1%
Quantity (metric tons/yr)	16,937,000	−310,146	−1.8%	−317,347	−1.9%
Domestic	16,751,000	−338,867	−2.0%	−346,792	−2.1%
Large	14,098,690	34,243	0.2%	31,447	0.2%
Small	2,652,310	−373,110	−14.1%	−378,239	−14.3%
Imports	186,000	28,721	15.4%	29,445	15.8%

and a reduction in domestic production of 1.8 percent under the scenario without PM CEMS requirements. The economic analysis also projects that two plants owned by small businesses will close as a result of the lime NESHAP.[4] In addition, the Agency estimates that employment in the lime production industry will be reduced by 98 employees under this scenario. This is a net change, taking into account increases in employment for some firms and decreases for others. Results are very similar for the PM CEMS option. Under that scenario, the price of lime is projected to increase by 2.1 percent while domestic production is expected to decline by 1.9 percent. As in the case without PM CEMS, two plants owned by small businesses are projected to close as a result of the regulation. The projected employment loss in this case is 100 workers.

Furthermore, the market adjustments in price and quantity allow calculation of the economic welfare impacts (i.e., changes in aggregate economic welfare as measured by changes in consumer and producer surplus). These estimates represent the social cost of the regulation. The estimated social cost of this regulation is $20.2 million without PM CEMS, with $19.7 million falling on consumers and $0.6 million falling on producers. For the scenario with PM CEMS, the social cost of the regulation is estimated to be $21.2 million,

[4]Plants owned by large firms are aggregated and represented by a single representative supplier because there is insufficient information to accurately characterize individual kilns or plants owned by large firms. Thus, closures are not determined for plants owned by large firms in this model.

with consumers bearing \$20.1 million of the costs and producers bearing \$1.0 million. The majority of the cost of this regulation ends up falling on consumers in the form of higher prices (and smaller quantities made available) based on the supply and demand elasticities used and the presence of projected closures. Although somewhat counterintuitive, the effect of the estimated closures is to shift more of the cost burden to consumers relative to the case where no closures occur. This is because the firms projected to close have relatively small estimated baseline pre-tax earnings from lime production such that producer surplus is not decreased all that much by reducing their pre-tax earnings to zero (due to closure). However, eliminating the quantity that this firm produced in the baseline from the market provides benefits to their competitors by driving up the market price. Based on the market characteristics used for this model, the increase in price received by all firms that continue to operate is sufficient to offset a significant portion of the compliance costs for producers and to shift more of the burden to consumers.

In addition to analyzing economic impacts on the lime manufacturing industry, EPA examined the impacts on the energy sector. EPA estimates that electricity consumption by existing sources would increase by about 7.2 million kWh per year as existing wet scrubbers are replaced with Venturi wet scrubbers, which require more electricity to operate. In addition, the projected decrease in lime output under regulation (1.8 to 1.9 percent reduction) is expected to lead to an approximately proportionate reduction in energy use by the lime industry. Both of these changes act to reduce the demand for electricity slightly. Thus, it is unlikely that there will be any significant adverse effects on production, distribution, or use resulting from this rule.

ES.4 Small Business Flexibility Analysis

The Agency prepared a Small Business Flexibility Analysis (SBFA) that examines the impact of the proposed rule on small entities within the lime manufacturing source category along with regulatory alternatives that could reduce impacts. EPA identified the businesses that this proposed rule will affect and conducted an economic analysis to determine whether this rule is likely to impose a significant impact on a substantial number of the small businesses within this industry. The Agency also convened a Small Business Advocacy Review (SBAR) panel to obtain advice and recommendations of representatives of the small entities that would potentially be subject to the rule. The current economic analysis reflects EPA's incorporation of Panel comments in the proposed rule, which has greatly reduced the impacts on small entities compared with draft versions of the proposed rule.

The small business analysis focuses on the economic impact of the proposed regulation on the 14 lime plants operating during 1997 that are owned by the 12 small commercial quicklime producers and an additional seven small firms that are either captive producers or only hydrate lime (i.e., they have no kilns and bear no direct costs).[5] Small commercial lime companies are defined according to the Small Business Administration (SBA) size standard for NAICS 327410 as those companies that own lime plants and have fewer than 500 total employees. For the captive lime operations, the primary NAICS code generally differs from the code for lime manufacturing. Thus, the small business definition differs from that for the commercial lime producers. Small companies that are beet sugar manufacturers (NAICS 311313) and pulp and paper mills (NAICS 322110 and 322121) are defined as those with fewer than 750 total employees, while small iron and steel mills (NAICS 331111) are defined as those with fewer than 1,000 total employees.

A summary measure of small business impacts is the ratio of annual compliance costs to baseline revenues (known as the cost-to-sales ratio, or CSR) at lime plants owned by small businesses. For this calculation, compliance costs are defined as the engineering control costs imposed on these plants and, thus, do not reflect the individual kiln or plant production responses to the imposition of these costs and the resulting market adjustments. For the proposed regulation, the CSR averages 1.6 percent for small companies and 0.01 percent for large commercial companies without PM CEMS. For the option with PM CEMS, the CSR averages 1.8 percent for small companies and 0.01 percent for large companies.[6] For the option without PM CEMS, 9 of 19 small lime companies are impacted above 1 percent of sales and 4 are affected above 3 percent of sales. For the option with PM CEMS, 10 of 19 small businesses are impacted above 1 percent of sales with four of those firms having costs greater than 3 percent of sales. Six small companies have zero costs either because they produce lime for use in beet sugar production or are hydrators only. In either case, they do not incur any direct costs.

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[5]Two companies own two plants; the other 17 companies own one lime plant apiece. These companies are identified in Section 2.4.1.

[6]Because compliance costs were not available for individual large companies, the CSR for large companies was calculated by dividing the total compliance costs for large companies estimated by the engineering analysis by their total company revenues. Total compliance costs for these companies are estimated based on the proportion of firms expected to receive each type of compliance cost.

Similar analysis of earlier provisions under consideration for inclusion in this rule indicated much greater impacts on small businesses than this proposed rule. In draft versions of this rule, the mean CSR for the small businesses was 2.6 percent without PM CEMS and 2.7 percent without PM CEMS. The Agency estimated that 10 small businesses would experience an impact greater than 3 percent of sales under both cost scenarios. The reduction in small business costs between earlier versions of this rule and the proposed rule are attributable to EPA's outreach and accommodation for small firms, which includes the conduct of the SBAR panel.

Additional measures of the economic impact provided by this analysis include the changes in revenues, costs, and earnings; the post-regulatory compliance costs; lime kiln and plant closures; and the change in employment attributable to the change in industry output. It was estimated that total pre-tax earnings for the commercial lime plants owned by small companies will decrease by 22.1 percent without PM CEMS and by 25.5 percent with PM CEMS while similar measures for plants owned by large companies are increases in pre-tax earnings of 3.5 percent without PM CEMS and 3.2 percent with PM CEMS. The market model predicts there will be two plant closures at small businesses both with and without PM CEMS. There is a large variation in impacts across small firms, however. The reduction in quantity due to the plant closure is increasing the price of lime for those firms that continue to operate. Therefore, although there is an overall decrease in pre-tax earnings, firms receiving small compliance costs may have their increase in cost more than outweighed by the increased market price. In this case, they will actually experience an increase in pre-tax earnings after regulation.

As a result of the SBAR panel, this rule contains a significant number of accommodations for small businesses. The results presented here confirm that the mitigating measures employed by the Agency have minimized the potential negative impacts of the proposed rule on small businesses while satisfying the objectives of the CAA. The share of small companies affected at or above the 3 percent level has fallen from 53 percent to 21 percent both with and without PM CEMS.

SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency (referred to as EPA or the Agency) is developing an air pollution regulation under Section 112 of the Clean Air Act (CAA) designed to reduce emissions generated in the production of lime. Lime is primarily used by chemical and industrial users, with the largest consumption among that group occurring in the steel industry. Other important categories of lime use include environmental applications, construction, and agriculture. Lime production leads to emissions of particulate matter (PM), including metals; hydrochloric acid (HCl); and gaseous pollutants, including carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), and nitrogen oxides (NO_x). The proposed rule is primarily intended to reduce the emissions of PM/metals from lime kilns. This report presents the results of an economic impact analysis (EIA) in which a market model was used to analyze the impacts of the proposed air pollution rule on directly and indirectly affected entities.

1.1 Agency Requirements for an EIA

Congress and the Executive Office have imposed statutory and administrative requirements for conducting economic analyses to accompany regulatory actions. Section 317 of the CAA specifically requires estimation of the cost and economic impacts for specific regulations and standards proposed under the authority of the Act. In addition, Executive Order (EO) 12866 requires a more comprehensive analysis of benefits and costs for proposed *significant* regulatory actions.[1] Other statutory and administrative requirements include examination of the composition and distribution of benefits and costs. For example, the Regulatory Flexibility Act (RFA), as amended by the Small Business Regulatory Enforcement and Fairness Act of 1996 (SBREFA), requires EPA to consider the economic impacts of regulatory actions on small entities. Finally, EO 13211 requires EPA to consider the effects of regulations on the supply, distribution, and use of energy. The Office of Air

[1] Office of Management and Budget (OMB) guidance under EO 12866 stipulates that a full benefit-cost analysis is required only for economically significant actions (i.e., when the regulatory action has an annual effect on the economy of $100 million or more).

Quality Planning and Standards (OAQPS) has developed the *OAQPS Economic Analysis Resource Document*, which provides detailed instructions and expectations for economic analyses performed by this office that support such rulemakings (EPA, 1999b).

1.2 Scope and Purpose

The CAA's purpose is to protect and enhance the quality of the nation's air resources (Section 101(b)). Section 112 of the CAA Amendments of 1990 establishes the authority to set a National Emission Standard for Hazardous Air Pollutants (NESHAP). This report evaluates the economic impacts of pollution control requirements placed on lime kilns under these amendments. These control requirements are designed to reduce releases of hazardous air pollutants (HAPs) into the atmosphere.

To reduce emissions of HAPs, the Agency establishes maximum achievable control technology (MACT) standards. The term "MACT floor" refers to the minimum control technology on which MACT standards can be based. For existing major sources,[2] the MACT floor is the average emissions limitation achieved by the best performing 12 percent of sources (if there are 30 or more sources in the category or subcategory). For new sources, the MACT floor must be no less stringent than the emissions control achieved in practice by the best controlled similar source. The MACT can also be chosen to be more stringent than the floor, considering the costs and the health and environmental impacts.

The proposed NESHAP will apply to all existing and new lime kilns used to produce lime for commercial sale located at plants that are major sources.[3] In addition, the regulation will apply to some kilns producing lime for captive use. The proposed rule will not affect lime plants associated with beet sugar producers or pulp and paper producers. However, firms in other industries involved in the production of lime for captive use (e.g., steel mills) will be subject to controls under this regulation. Based on emissions data, EPA has determined that approximately 150 lime kilns are located at major sources and will be

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[2]A major source is defined as a stationary source or group of stationary sources located within a contiguous area and under common control that emits, or has the potential to emit considering control, 10 tons or more of any one HAP or 25 tons or more of any combination of HAPs.

[3]The USGS identifies 11 plants that solely hydrate lime (DOI, 2000). By definition, these plants do not have lime kilns, but purchase quicklime from other plants to use in their production of hydrated lime. Because these plants do not have lime kilns, they will not be directly affected by the lime NESHAP.

directly affected by the rule. However, it is unknown which kilns are located at major sources.[4]

This report analyzes the economic effects of the MACT standard on existing sources using a baseline of 1997. New plants will also be required to comply with this rule, but EPA does not anticipate any differential impacts on these sources. Thus, the economic impact analysis described in Section 4 focuses on the regulatory effects on existing sources only.

1.3 Organization of the Report

The remainder of this report is divided into four sections that describe the methodology and present results of this analysis:

- Section 2 provides a summary profile of the production of lime. It presents data on the manufacturing process, market volumes and prices, manufacturing facilities, and the companies that own and operate those facilities.
- Section 3 reviews the regulatory control options and associated costs of compliance. This section is based on EPA's engineering analysis conducted in support of the proposed NESHAP.
- Section 4 describes the methodology for assessing the economic impacts of the proposed NESHAP and presents the results of the economic analysis, including market, industry, and social cost impacts. In addition, this section describes the economic impacts of this rule on the energy sector.
- Section 5 provides the Agency's analysis of the regulation's impact on small businesses.

In addition to these sections, Appendix A further details the economic model used to predict the economic impacts of the NESHAP and Appendix B presents the results of sensitivity analyses where the supply and demand elasticities used in the market model are varied.

[4]The exception to this is for kilns owned by small businesses. EPA gathered more detailed information on these kilns as part of ensuring compliance with SBREFA requirements. Thus, EPA was able to determine whether plants owned by small businesses are major sources or area sources. There were not sufficient resources available to gather this level of information for all affected kilns.

SECTION 2

INDUSTRY PROFILE

Although lime serves as an important input to production in many industries, the manufacturing of lime results in the emission of HAPs. Therefore, EPA has compiled information on lime manufacturing plants as part of its responsibility to develop NESHAPs under the CAA. This industry profile of the lime manufacturing industry provides information to support the regulation. The purpose is to provide a general understanding of the technical and economic aspects of the industry that must be addressed in the EIA.

The production of lime begins with the quarrying and crushing of limestone. The crushed limestone is then converted into lime by heating the limestone in a kiln, a process known as calcination. When limestone is subjected to high temperatures, it undergoes a chemical decomposition resulting in the formation of lime (CaO) and the emission of CO_2. Because calcination is a reversible chemical reaction, the CO_2 emitted as a result of the process must be removed to prevent recarbonation.

Lime as it exits the kiln is known as quicklime. It can be either high calcium or dolomitic, depending on the type of limestone that was calcined. After the quicklime leaves the kiln, it is screened to remove undersized particles. Quicklime can be converted into hydrated lime by adding water. Hydrated lime is produced in a vessel called a hydrator, where a precise amount of water is slowly added to crushed or ground quicklime and the mixture is stirred and agitated. The hydrated lime may undergo further refining or proceed directly to bagging, shipment, and/or storage.

Dead-burned dolomite, also called refractory lime, is a sintered or double-burned form of dolomitic lime. It is used for lining open hearth or electric arc steel furnaces or as an input in the refractory bricks that line basic oxygen steel furnaces. Dead-burned dolomite represented less than 2 percent of total U.S. lime production in 1999 (Miller, 1999a).

Lime manufacturing falls under the Standard Industrial Classification (SIC) code 3274 (North American Industrial Classification System [NAICS] code 32741). All three types of lime output mentioned above are included in the same SIC and NAICS codes.

According to the 1997 Census of Manufactures, 85 establishments owned by 47 companies manufactured lime for commercial sale in 1997 (U.S. Department of Commerce, 1999b). In 1999, production of lime occurred at approximately 257 kilns (EPA, 2000). In 1999, 108 plants across the United States were involved in lime production. However, 11 of these plants are identified by the U.S. Geological Survey (USGS) as hydrating plants only (DOI, 2000), which, by definition, do not have any operating kilns. This implies that the average number of operating kilns for the 97 plants that have kilns is approximately 2.6 kilns per plant.

During 1999, the United States produced 19.6 million metric tons of lime, with quicklime accounting for 87.2 percent of all lime production and hydrated lime accounting for 11.3 percent of lime production. The remaining 1.5 percent of lime production was dead-burned dolomite. The total value of domestic lime shipments in 1999 was \$1.2 billion, for an average value of \$60.10 per metric ton. In 1997, the baseline year chosen for this analysis, there were about 19.1 million metric tons of quicklime produced in the U.S. and the average price of quicklime was \$56.60/metric ton.

The remainder of this section provides a brief introduction to the lime manufacturing industry. Section 2.1 presents a brief overview of the production process. Section 2.2 provides historical market data on U.S. production, consumption, foreign trade, and prices. Section 2.3 describes the affected U.S. processing facilities and the companies that own them. Finally, Section 2.4 provides data on the consumers and uses of lime and related products.

2.1 Lime Production

This section gives a brief overview of the lime production process, the different types of kilns used in lime manufacturing, the major inputs into lime production, and the emissions resulting from this production process.

2.1.1 General Production Process

As shown in Figure 2-1, the general production process for producing lime consists of

- quarrying and crushing limestone,
- heating the limestone in a kiln to convert it into quicklime (calcination),

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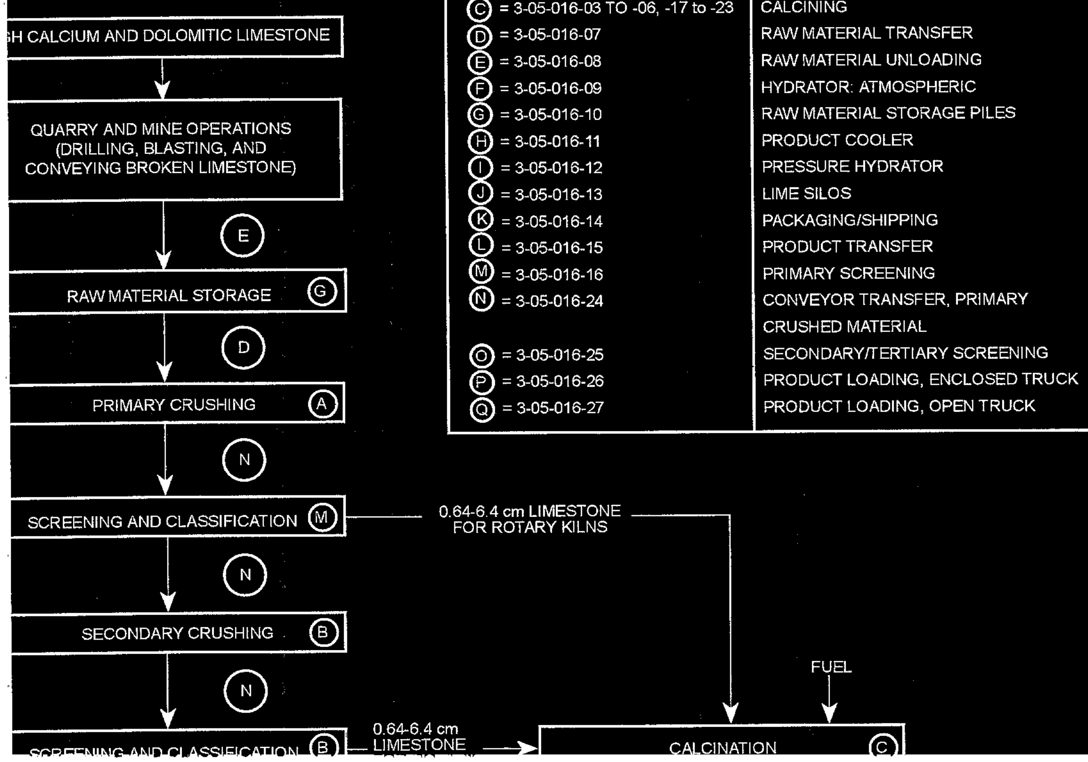
SCC	DESCRIPTION
A = 3-05-016-01	PRIMARY CRUSHING
B = 3-05-016-02	SECONDARY CRUSHING/SCREENING
C = 3-05-016-03 TO -06, -17 to -23	CALCINING
D = 3-05-016-07	RAW MATERIAL TRANSFER
E = 3-05-016-08	RAW MATERIAL UNLOADING
F = 3-05-016-09	HYDRATOR: ATMOSPHERIC
G = 3-05-016-10	RAW MATERIAL STORAGE PILES
H = 3-05-016-11	PRODUCT COOLER
I = 3-05-016-12	PRESSURE HYDRATOR
J = 3-05-016-13	LIME SILOS
K = 3-05-016-14	PACKAGING/SHIPPING
L = 3-05-016-15	PRODUCT TRANSFER
M = 3-05-016-16	PRIMARY SCREENING
N = 3-05-016-24	CONVEYOR TRANSFER, PRIMARY CRUSHED MATERIAL
O = 3-05-016-25	SECONDARY/TERTIARY SCREENING
P = 3-05-016-26	PRODUCT LOADING, ENCLOSED TRUCK
Q = 3-05-016-27	PRODUCT LOADING, OPEN TRUCK



- cooling,
- crushing and pulverizing the quicklime, as necessary (quicklime is available in various sizes), and
- reacting quicklime with water (for hydrated lime only).

A more detailed description of the production process is provided below.

The first step of lime manufacturing involves crushing the limestone into smaller pieces. Limestone is then converted into lime through heating in a kiln, a process known as calcination. When limestone is subjected to high temperatures, it undergoes a chemical decomposition resulting in the formation of lime (CaO) and the emission of CO_2. Because calcination is a reversible chemical reaction, the CO_2 emitted as a result of the process must be removed to prevent recarbonation.

At this point in the production process, the lime is referred to as quicklime. Quicklime can be either high-calcium or dolomitic, depending on the type of limestone that was calcined. After the quicklime leaves the kiln, it is screened to remove fines and undersized particles. Quicklime is sold in the following forms: lump (6.35 cm to 30.5 cm), pebble (6.35 mm to 6.35 cm pieces), ground (particles less than 2.38 mm), pulverized (particles less than 0.84 mm), or briquette (fines that are molded into lumps) (Boynton, 1980).

In general, quicklime must be converted into hydrated lime before being used as an input into a production process.[1] The process of hydration, also known as slaking, is a chemical reaction between lime and water. Hydrated lime is produced in a vessel called a hydrator, where a precise amount of water is slowly added to crushed or ground quicklime and the mixture is stirred and agitated. The gas resulting from the hydration process contains steam and lime particles. This gas may be vented back into the kiln or sent to a control device where it is cleaned and then released (EPA, 1996).

Another type of lime that may be produced is dead-burned dolomite, also called refractory lime. Dead-burned dolomite is produced by sintering or double-burning dolomitic lime, a type of lime that has a relatively high magnesium content of between 35 and 46

[1]However, most lime is purchased from lime manufacturing facilities as quicklime and is hydrated by buyers in their own onsite facilities prior to use.

percent. This type of lime is used for lining open hearth or electric arc steel furnaces or as an input in the refractory bricks that line basic oxygen steel furnaces.

2.1.2 Kiln Types

Lime kilns can be categorized into three groups: rotary kilns, vertical kilns, and miscellaneous. About 90 percent of commercial lime capacity in the U.S. is calcined in rotary kilns. Most of the remaining capacity is processed with vertical kilns (vertical kilns are more common in captive supply facilities), and small quantities are processed in other miscellaneous types of kilns such as calcimatic, fluidized bed, pot, etc. (Gutschick, 1994).

2.1.2.1 Rotary Kilns

Figure 2-2 illustrates a rotary kiln system with a preheater. A rotary kiln is a long cylinder, ranging in length from 75 to 500 feet, with a diameter between 4 and 11 feet. This cylinder is set at an incline of 3 to 5 degrees and rotates at a rate of 35 to 80 revolutions per hour. The inner surface of the cylinder is lined with refractory brick. Surrounding the brick is a layer of insulation, then an outer casing of steel boiler plate.

Before entering the kiln, the limestone passes through the preheater, where it is heated with hot exhaust gases from the kiln. Preheaters improve thermal efficiency by using heat from the kiln that might otherwise be lost (Boynton, 1980). Burning fuel enters the cylinder from the lower end, and pre-heated limestone is delivered into the upper end. As the limestone passes through the cylinder that is filled with flame and hot combustion gases, it calcines into lime, which is discharged at the lower end of the cylinder (Boynton, 1980).

Lime must be cooled after exiting the rotary kiln. Various types of coolers are used, including contact coolers, satellite coolers, rotary coolers, and grate coolers. These coolers operate under different principles, but they serve the same two purposes: to cool the lime for further handling and to recapture heat. The first two types listed are the most commonly used because they are the most effective at heat recuperation (Boynton, 1980). Most rotary kilns are fired by coal; however, with the correct adaptations, coke, oil, and natural gas can also be used (Gutschick, 1994).

The refractory brick linings in all kilns must be replaced periodically, because heat, abrasion, and temperature changes cause them to disintegrate. Plants try to avoid cooling and reheating lime kilns as much as possible because this hastens disintegration. When plants need to stop production, they will often slow-fire the kilns or maintain their heat until

Figure 2-2. Preheater Rotary Kiln System for Lime Production

Source: Gutschick, K.A. 1994. "Lime and Limestone." *Kirk-Othmer Encyclopedia of Chemical Technology*. 4th Ed. p. 319-359. Vol. 15. New York: John Wiley & Sons.

production resumes. It is generally less costly to keep the kilns hot than it is to replace the linings or to restart the kilns (Boynton, 1980).

2.1.2.2 Vertical Kilns

The vertical kiln has many different variations, but all operate under the same general premise. Figure 2-3 is a diagram of a vertical kiln. Vertical kilns are large vertical cylinders that are completely filled from the top with large chunks of limestone. These kilns have four zones, or sections: the preheating zone, the calcining zone, the finishing zone, and the cooling zone. These zones are not physically separated from one another. They are terms used to indicate areas within the kiln, which is a continuous cylinder.

Burning fuel is injected into the cylinder just beneath the calcining zone, causing the limestone in this zone to calcine. Hot gasses from the calcining zone migrate upward, warming the stone in the preheating zone. Finished lime drops into the cooling zone, where cool air is blown through it. Air blown into the cooling zone carries recovered heat upward into the calcining zone, where it also provides air for combustion. Cooled lime is removed from the bottom, making room for the limestone and lime in the upper levels to descend.

Figure 2-3. Vertical Kiln System for Lime Production

Source: Gutschick, K.A. 1994. "Lime and Limestone." *Kirk-Othmer Encyclopedia of Chemical Technology.* 4th Ed. p. 319-359. Vol. 15. New York: John Wiley & Sons.

Some vertical kilns require an attendant to determine when calcining is complete. The attendant must open "poke holes" in the kiln and dislodge the mass of hot lime with a long iron bar, allowing it to drop down into the cooling zone (Boynton, 1980). The predominant fuels for vertical kilns are natural gas and fuel oil (Boynton, 1980).

Vertical kilns require large stones (6 to 8 inches in diameter) to allow for the circulation of combustion gases. Stones that are too small to be used are called "spalls." Large quantities of spalls can accumulate at plants with vertical kilns and can be difficult or impossible to dispose of profitably. Depending on the source of limestone, spalls can constitute from 30 to 70 percent of the limestone intended for use as kiln feed. Rotary kilns can use small stones that calcine faster and lead to fewer spalls. To solve the problem of spalls, some plants have installed rotary kilns in addition to vertical kilns. European researchers have developed vertical kilns that can use small stones, but this technology has not been implemented in the United States (Boynton, 1980).

For a number of reasons, rotary kilns have largely replaced vertical kilns in the United States. They dominate the industry because they can be fired with coal, require less labor, lead to fewer spalls, and have the highest output and quality of all kilns (Boynton, 1980; Gutschick, 1994). In contrast, vertical kilns are preferred in many other parts of the world. They require smaller capital investment and have greater fuel efficiency than rotary kilns.

2.1.2.3 Miscellaneous Kiln Types

Parallel-flow kilns are beginning to gain acceptance in the United States. These kilns are made up of two side-by-side vertical shafts that are similar to vertical kilns (see Figure 2-4). The two shafts are connected in the middle, allowing gases to flow from one shaft to the other. The shafts alternate functions: while one is acting as the calcining shaft, the other serves as the preheating shaft. Limestone fills the shafts from the top. Hot combustion gases are fired down the first shaft, calcining the lime. The exhaust then flows across and up through the second shaft, preheating the lime. Every 12 to 14 minutes, the flow is reversed. The lime is cooled in the bottom section of each shaft with a countercurrent flow of air. Finished lime exits from the bottom of each shaft. Parallel-flow kilns can be fired with natural gas or oil. They are energy-efficient and produce high-quality lime (EPA, 1996; Sauers, Beige, and Smith, 1993b).

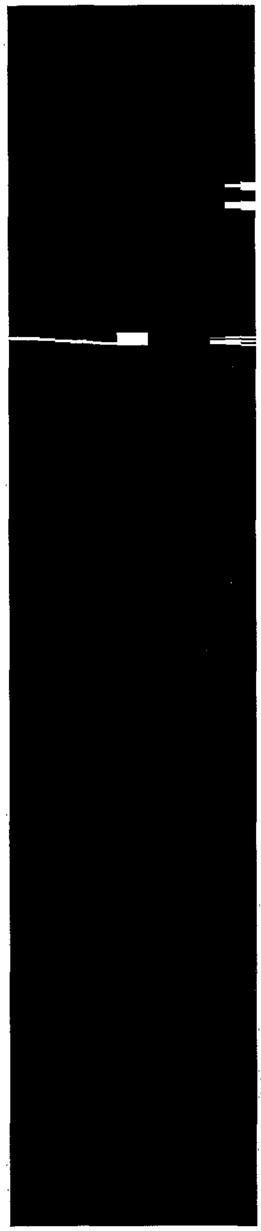


Figure 2-4. Parallel Flow Kiln with Left Shaft Calcining and Right Shaft Preheating

Source: U.S. Environmental Protection Agency. 1996. Memorandum from Wood, Joseph P., U.S. Environmental Protection Agency, to Chappell, Linda M., U.S. Environmental Protection Agency. November 6, 1996. Engineering industry profile for the economic analysis.

The Fluo-Solids kiln, which is a fluidized-bed system, looks like a vertical kiln on the outside but operates on a different principle (see Figure 2-5). It calcines tiny (0.23 to 2.38 m) particles of limestone. These tiny particles are "fluidized," or suspended in air in the preheating and calcining zones of the kiln. These kilns require external cooling equipment, as described in the section on rotary kilns. Because small particles will burn at lower temperatures, these kilns have relatively low fuel consumption. They also produce consistently high-quality lime. However, the cost of providing such finely ground limestone as kiln feed prohibits the use of these kilns in most areas (Boynton, 1980).

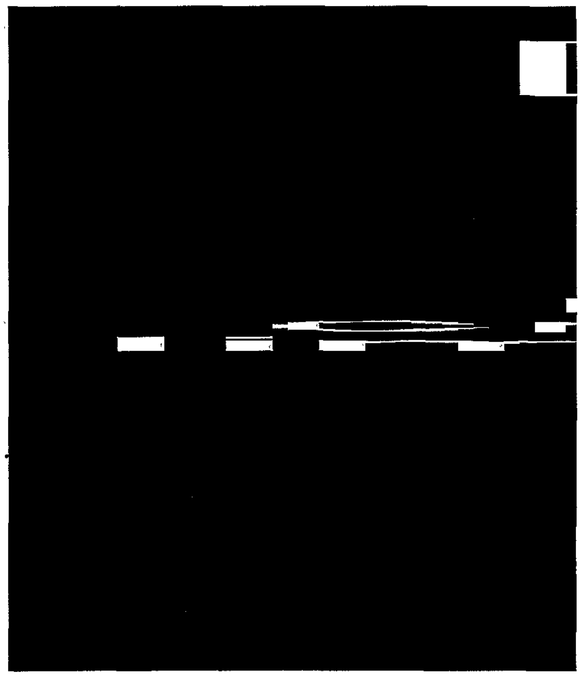


Figure 2-5. Fluidized Bed Kiln

Source: U.S. Environmental Protection Agency. 1996. Memorandum from Wood, Joseph P., U.S. Environmental Protection Agency, to Chappell, Linda M., U.S. Environmental Protection Agency. November 6, 1996. Engineering industry profile for the economic analysis.

The calcimatic kiln (also called a rotary hearth kiln) consists of a circular hearth that rotates through a kiln (see Figure 2-6). Preheated limestone is loaded onto the hearth. It rotates through the kiln, and finished lime is removed from the hearth after one complete rotation. External cooling equipment is also used. These kilns have not been widely accepted because they can only operate with gas and oil and have poor fuel efficiency (Boynton, 1980).

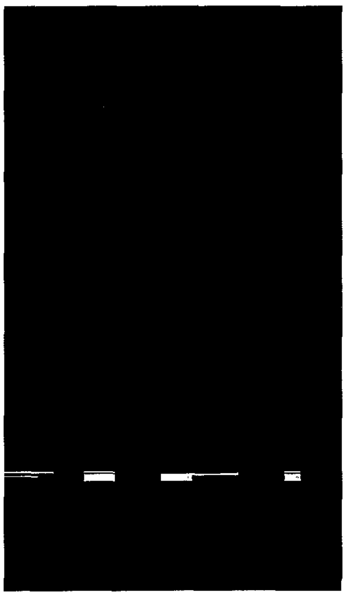


Figure 2-6. Rotary Hearth Kiln with Cross Sectional View of One Firing Zone

Source: U.S. Environmental Protection Agency. 1996. Memorandum from Wood, Joseph P., U.S. Environmental Protection Agency, to Chappell, Linda M., U.S. Environmental Protection Agency. November 6, 1996. Engineering industry profile for the economic analysis.

2.1.3 *Major Inputs for Lime Production*

The inputs in the production process for lime include general inputs such as labor and capital. The inputs that are specific to this industry are the types of fuel used and the limestone or other calcareous material used. These two specific inputs are discussed below.

2.1.3.1 Fuel

Lime production is extremely energy intensive. Assuming perfect efficiency, producing a ton of lime from pure calcium carbonate requires 2.77 million Btu. In practice, the process is considerably less efficient. Lime producers are concerned about the quality of fuel used in the process because the quality of the resulting lime depends directly on fuel quality. A change in fuel source can lead to a noticeable change in the characteristics of the lime produced. For this reason, lime producers do not always choose the cheapest fuel available (Boynton, 1980). The fuels most widely used in lime production in the United States are coal, coke, natural gas, and fuel oil (Sauers, Beige, and Smith, 1993a). A brief discussion of each fuel follows.

Coal. During the energy crisis of the 1970s, when fuel oil and natural gas prices soared and supplies were limited, many lime producers switched from vertical kilns to rotary kilns that operate with cheaper, more plentiful coal (Gutschick, 1994). To produce the highest quality lime, coal must be of moderate to low reactivity. (Reactivity refers to how freely the coal burns.) Coal used to fire lime kilns should also have a low ash content, since ash provides no heat value, can damage kiln linings, and may contaminate the lime. A low sulphur content is also desirable. Sulfur in the fuel volatilizes at calcining temperatures and might contaminate the lime (Boynton, 1980).

Coke. Coke can be produced from either coal or petroleum. Coke is the solid material that remains after coal has been heated in coke ovens until volatile components are driven off and collected as coal tar. It is also the solid material remaining after the various fractions of crude oil have been distilled off during the process of refining petroleum (Caldwell, 1998).

Coke is lower in both ash and volatiles than coal. Fuels that are high in volatiles create a stable flame, which is required by rotary kilns. Because coke is low in volatiles, it cannot be used exclusively in rotary kilns but can be mixed with coal to reduce ash. Kilns that do not require a stable flame formation, such as the parallel flow kiln, can burn 100 percent coke (Sauers, Beige, and Smith, 1993a).

Natural Gas. Natural gas is relatively clean burning and is consistent in quality; therefore, it produces the highest quality lime. Natural gas-fired kilns require about 10 percent more energy than coal-fired kilns, however, and the cost per million Btu is generally much higher for natural gas than for coal. Kilns operating with natural gas also require more combustion air and larger vent capacity (Sauers, Beige, and Smith, 1993a).

Fuel Oil. Because fuel oil generally costs more per million Btu than coal or natural gas, it is seldom used as the primary source of fuel in lime kilns, but it is sometimes combined with other fuels. It is low in ash and produces high-quality lime (Sauers, Beige, and Smith, 1993a).

Fuel oils, which are used mostly in nonrotary kilns, are usually Bunker C grade. Fuel oil has a greater potential for heat generation than solid fuels. When fuel oil is used, the kiln operation must be closely monitored to avoid excessive temperatures and overburning (Boynton, 1980).

2.1.3.2 Limestone

Limestone is a general term that refers to a variety of sedimentary rocks. Limestone can be either high calcium or dolomitic, depending on its magnesium content. The type of limestone used by a particular facility is determined by the type of limestone that is available in nearby quarries. Deposits of limestone occur in nearly every state of the United States and every country in the world. However, much of it is not available for commercial use because it is either too deep in the earth, too far from markets, not sufficiently concentrated in a particular area, or not pure enough (Boynton, 1980).

2.1.4 Emissions

Lime production leads to emissions of PM; metals; HCl; and gaseous pollutants, including CO, CO_2, SO_2, and NO_x (Midwest Research Institute, 1994; EPA, 1996). Emission points are indicated by Source Classification Code (SCC) in Figure 2-1.

2.1.4.1 Particulate Matter and Metals Emissions

The kiln is the largest ducted source of PM and metals emissions from lime production. PM and metals emissions can also occur from coolers, but only in plants where exhaust gases are not recycled back through the kiln. Emissions from ordinary hydrators are generally readily controlled, whereas emissions from pressure hydrators are somewhat more difficult to control. In addition to these sources, PM and metals emissions can also occur at primary and secondary crushers, mills, screens, transfer points, storage piles, and roads. Drilling and blasting at the quarry also create PM and metals emissions.

Rotary lime kilns constructed or modified after May 3, 1977, are required by law to limit their emissions of filterable PM to 0.30 kg/Mg (0.60 lb/ton) of stone feed. Devices used to control PM emissions from kilns are fallout chambers and cyclone separators for large particles and fabric or gravel bed filters, wet scrubbers, and electrostatic precipitators for smaller particles. Cyclones, fabric filters, and wet scrubbers are also used to control PM emissions from coolers, crushers, and loaders (Midwest Research Institute, 1994).

Rotary kilns have high potential PM and metals emissions relative to other types of kilns, because they calcine small pieces of stone using high air velocities and a rotating chamber. Vertical kilns have very low PM and metals emissions because they process large chunks of stone using low air velocities, and the material moves slowly through the kiln. Fluidized bed kilns can potentially produce large amounts of PM and metals emissions, because they process fine particles in large volumes of air. But emissions from these kilns are generally well controlled. Calcimatic kilns have relatively low PM and metals emissions (Midwest Research Institute, 1994). The characteristics of the kiln feed and, if coal is used, the ash content of the coal can also influence PM and metals emissions (EPA, 1995).

2.1.4.2 Hydrochloric Acid

HCl is a combustion by-product emitted by the kiln that originates from the trace chlorine/chlorides found in the fuels used in lime production (e.g., coal) and the limestone input. The amount of HCl being emitted from a kiln is often measured as a proxy for the emissions of other HAPs and PM. The level of HCl being emitted is often a major determinant of whether a particular lime plant is classified as a major source of air pollution.

2.1.4.3 Gaseous Pollutants

As previously mentioned, CO, CO_2, SO_2, and NO_x are produced along with lime. The source of most SO_2 emissions is the fuel used to fire the kiln. The composition of the kiln feed, the quality of the lime being manufactured, and the type of kiln affect the amount of SO_2 produced. Most of the SO_2 from the kiln fuel is never released because it reacts with the lime within the kiln. Pollution control equipment can further limit SO_2 emissions (Midwest Research Institute, 1994).

In addition to the gaseous pollutants created by burning fossil fuels, the chemical reaction that occurs during calcination produces a large volume of CO_2. Limestone is approximately 44 percent CO_2 by weight, and this CO_2 is released during calcination (Miller, 1997).

2.2 Historical Industry Data

This section presents information on the markets for lime, including historical data for production, exports, imports, apparent consumption, and the price of lime as well as production costs.

2.2.1 Quantity Data

Table 2-1 provides data on domestically produced quicklime, hydrated lime, and dead-burned dolomitic lime from 1971 through 1999. In 1999, quicklime accounted for over 87 percent of all lime production, while hydrated lime made up over 11 percent of production, and dead-burned dolomite accounted for less than 2 percent. After decreasing significantly between the 1970s and the 1980s, lime production generally expanded throughout the mid to late 1990s.

Because limestone is plentiful in the U.S., and transportation for such a heavy, bulky commodity is expensive, imports make up only a small portion of total consumption of lime. Table 2-2 displays quantities of exports and imports, both metric tons and as percentages of production and consumption from 1971 through 1999. During this period, imports averaged only 1.63 percent of total consumption. Similarly, lime exports consist of a small percentage of total production. Approximately 0.29 percent of lime produced was exported over the period from 1971 to 1999 (see Table 2-2). The average value of lime exports between 1991 and 1999 was slightly less then $8 million dollars per year (1999$). The great majority of imported lime comes from Canada, with the balance coming almost entirely from Mexico. Most exported lime goes to Canada, and small amounts are exported to Jamaica and Mexico.

2.2.2 Price Data

Average lime prices between 1971 and 1999 are presented in both current and 1999 dollars in Table 2-3. The real (inflation-adjusted) price of lime ranges from $54.88 per metric ton in 1973 to $74.56 per metric ton in 1978. The real price has been on a downward trend since 1986.

Table 2-2. Exports and Imports of Lime: 1971-1999

	Exports (10^3 metric tons)	Exports as a Percentage of Production	Imports for Consumption (10^3 metric tons)	Imports as a Percentage of Consumption
1971	60	0.34	220	1.23
1972	34	0.18	225	1.21
1973	34	0.18	303	1.56
1974	29	0.15	377	1.89
1975	49	0.28	235	1.34
1976	51	0.28	331	1.78
1977	30	0.17	384	2.08
1978	41	0.22	553	2.90
1979	41	0.22	581	2.97
1980	38	0.22	435	2.47
1981	25	0.15	457	2.61
1982	21	0.16	316	2.42
1983	25	0.19	257	1.87
1984	23	0.16	224	1.53
1985	17	0.12	176	1.22
1986	15	0.11	182	1.37
1987	12	0.08	161	1.12
1988	14	0.09	191	1.22
1989	29	0.19	198	1.26
1990	40	0.25	157	0.98
1991	47	0.3	158	1.00
1992	59	0.36	193	1.18
1993	69	0.41	201	1.19
1994	74	0.43	204	1.17
1995	72	0.39	289	1.55
1996	50	0.26	262	1.36
1997	80	0.41	274	1.39
1998	56	0.28	231	1.15
1999	60	0.29	142	0.69

Sources: Miller, M.M. 1996c. Minerals Information: Lime Statistical Compendium. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey.
Miller, M.M. 1995. Minerals Information: Lime. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey.
Miller, M.M. 1996b. Minerals Information: Lime. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390300.pdf>.

Table 2-3. Average Lime Prices: 1971-1999

	Total Value[a] ($\$10^3$)	Average Value per Metric Ton	
		(Current $)	(1999$)
1971	308,100	17.39	58.70
1972	339,304	18.50	59.79
1973	365,849	19.20	54.88
1974	473,685	24.27	58.35
1975	523,805	30.27	66.67
1976	609,010	33.28	70.06
1977	666,472	36.93	73.19
1978	749,667	40.52	74.56
1979	862,459	45.48	74.33
1980	842,922	49.05	70.26
1981	884,197	51.82	68.01
1982	696,207	54.53	70.10
1983	757,611	56.33	71.52
1984	811,183	56.35	69.90
1985	809,000	56.98	71.02
1986	757,867	57.87	74.29
1987	786,125	55.24	69.12
1988	817,893	53.04	63.82
1989	852,113	54.93	62.97
1990	901,549	57.09	63.14
1991	890,000	56.69	62.59
1992	950,000	58.60	64.31
1993	965,000	57.60	62.31
1994	1,020,000	58.80	62.82
1995	1,100,000	59.20	61.06
1996	1,140,000	61.50	61.06
1997	1,200,000	61.00	62.45
1998	1,210,000	60.40	60.60
1999	1,180,000	60.10	60.10

[a] Values are selling values, f.o.b. plant, excluding costs of containers.

Sources: Miller, M.M. 1996c. Minerals Information: Lime Statistical Compendium. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey.
Miller, M.M. 1999a. Minerals Information: Lime. Reston, VA: U.S. Department of Interior, U.S. Geological Survey. <minerals.usgs.gov/minerals/pubs/commodity/lime/390499.pdf>.

2.2.3 *Production Costs*

Table 2-4 provides expenditures for wages, materials, and new capital in lime manufacturing from 1977 to 1997 in both current and 1997 dollars. Costs of materials include all raw materials, containers, scrap, and supplies used in production, repair, or maintenance during the year, as well as the cost of all electricity and fuel consumed. Costs are included for material whether they are purchased from outside the company or transferred from within the company.[2] New capital expenditures include permanent additions and alterations to facilities and machinery and equipment used for expanding plant capacity or replacing existing machinery.

The cost of materials is by far the greatest cost to lime producers. Lime producers spend three to four times more on material than they do on labor, with a large portion of the costs being fuels. For 1996, the Annual Survey of Manufactures reported that the lime industry spent $138.2 million on energy, which is 31.4 percent of total material costs for that year (U.S. Department of Commerce, 1997) The inputs that are specific to this industry are the type of fuel and the limestone or other calcareous material used. The fuels most widely used in lime production in the United States are coal, coke, natural gas, and fuel oil (Sauers, Beige, and Smith, 1993a).

2.3 Affected Producers

The following section briefly describes lime processing facilities and the companies that own them. It also presents the information used to determine the proportion of lime output produced by affected facilities versus unaffected facilities.

2.3.1 *Manufacturing Facilities*

Lime manufacturing plants can be broadly divided into those that produce lime to be sold (commercial lime plants) and those that produce lime as part of a vertically integrated production process whose purpose is to produce another good, such as steel, paper, or beet sugar (captive lime plant). Table 2-5a lists all of the commercial lime facilities in the 50 states and Puerto Rico and provides location, capacity, and kiln information. Alabama has the largest number of commercial lime facilities (seven) in the country, followed by Pennsylvania and Ohio with six each. Table 2-5b presents the location and kiln information for the U.S. captive supply lime industry. Michigan has the largest number of captive supply

[2]The cost of materials includes the cost of quarrying limestone.

[redacted]

(cont'd)

[redacted]

Table 2-5b. Captive Supply Lime Manufacturing Plants

Company	Facility	Location	Type of Kiln[a]
Amalgamated Sugar Co., The	Twin Falls	Twin Falls, ID	V
Amalgamated Sugar Co., The	Nampa	Nampa, ID	O
Amalgamated Sugar Co., The	Mimi-Cassia	Paul, ID	V
Amalgamated Sugar Co., The	Nyssa	Nyssa, OR	NA
American Crystal Sugar Co.	Moorhead	Moorhead, MN	NA
American Crystal Sugar Co.	Crookston	Crookston, MN	V
American Crystal Sugar Co.	East Grand Forks	East Grand Forks, MN	V
American Crystal Sugar Co.	Drayton	Drayton, ND	V
American Crystal Sugar Co.	Hillsboro	Hillsboro, ND	NA
Baker Refactories Co.	York	York, PA	R
Bowater Southern Paper Corp.	Calhoun	Calhoun, TN	R
Dow Chemical Co., The	Ludington	Ludington, MI	R
Elkem Metals Co.	Ashtabula	Ashtabula, OH	V
Graymont Ltd :(Continental Lime, Inc.)	Tacoma	Tacoma, WA	R
Great Lakes Sugar Co., The	Fremont	Genoa, OH	O
Holly Sugar Corp.	Brawley	Brawley, CA	V
Holly Sugar Corp.	Tracy	Tracy, CA	V
Holly Sugar Corp.	Woodland	Woodland, CA	V
Holly Sugar Corp.	Sidney	Sidney, MT	V
Holly Sugar Corp.	Hereford	Herford, TX	V
Holly Sugar Corp.	Torrington	Torrington, WY	V
Holly Sugar Corp.	Worland	Worland, WY	V
Ispat Inland, Inc.	Indiana Harbor	Indiana Harbor, IN	R
LTV Steel	Grand River	Grand River, OH	R
Martin Marietta Magnesia Specialties, Inc.	Woodville	Woodville, OH	V
Michigan Sugar Co.	Sebewaing	Sebewaing, MI	V
Michigan Sugar Co.	Carolton	Carolton, MI	V
Michigan Sugar Co.	Croswell	Croswell, MI	V
Michigan Sugar Co.	Caro	Caro, MI	V
Minn-Dak Farmers Coop.	Minn-Dak	Wahpeton, ND	V
Monitor Sugar Co.	Bay City	Bay City, MI	V
NorthWest Alloys, Inc.	Addy	Addy, WA	R
Riverton Corp.	Riverton	Riverton, VA	V
Southern Minnesota Sugar Corp.	Renville	Renville, MN	V
Specialty Minerals, Inc.	Adams	Adams, MA	O
Western Sugar Co.	Fort Morgan	Fort Morgan, CO	V
Western Sugar Co.	Greeley	Greeley, CO	O
Western Sugar Co.	Bayard	Bayard, NE	O
Western Sugar Co.	Mitchell	Mitchell, NE	V
Western Sugar Co.	Scottsbluff	Scottsbluff, NE	V
Western Sugar Co.	Billings	Billings, MT	V

[a] R = rotary; V = vertical or shaft; O = other; NA = not available

Source: U.S. Department of the Interior, U.S. Geological Survey. 2000. *1999 Directory of Lime Plants in the United States. Mineral Industry Surveys*. Reston, VA. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/index.html#myb>.

lime facilities, with six, followed by Minnesota with four and California, Idaho Nebraska, North Dakota, and Wyoming with three facilities each.

In 1999, the United States lime industry overall operated at 76 percent capacity, down from a rate of 79 percent the previous year (Miller, 1999b). Rates of capacity utilization ranged between about 65 percent and 88 percent depending on region. Between 1995 and 1999 the lime industry increased capacity more than it increased production, leading to the decline in the rate of capacity utilization during that period. There has been rapid consolidation in the industry over the past few years with accompanying renovations, closings, and expansion of several plants.

2.3.2 Companies

Using information obtained from the USGS (DOI, 2000), the Information Access Corporation (Information Access Corporation, 1997), American Business Information (ABI, 1997), Dun & Bradstreet (2000), Gale Group (1999), Hoover's Online, Lycos Small Business Online, and Reference USA (2000), 45 companies were identified that produce lime for either commercial or captive supply purposes. Twenty-five of these companies produce lime solely for the commercial market, while 20 engage in captive production, either entirely, or in combination with some commercial production. Data on companies owning lime plants are shown in Table 2-6. This table lists information on organization type, number of facilities, sales, employment and parent companies for commercial and captive producers. Data are incomplete for some of these companies, typically because they are privately held subsidiaries.

The *Concise McGraw-Hill Dictionary of Modern Economics* provides the following definition of horizontal integration: "The situation existing in a firm whose products or services are competitive with each other, the term also applies to the expansion of a firm into the production of new products that are competitive with older ones. Horizontal integration may be the result of a merger of competing firms in the same market, or involve expansion of a firm from its original base to a wider area, as in the case in the growth of retail chains. The advantages of horizontal integration stem primarily form economies of large-scale management, large-scale buying from supplies, and large-scale distribution. Horizontal integration may result in a monopoly in a particular market" (Greenwald, 1984). According to this definition, there is some evidence of horizontal integration among both the commercial and captive lime producers. Among commercial producers, 11 companies

Table 2-6. Company-Level Data for the Lime Industry

Ultimate Parent Company Name	Number of Lime Plants	Sales (10^6)	Employment	Small Business	Type
Ash Grove Cement Co.	2	$365	1,800	No	M
Austin White Lime Co.	1	$15	150	Yes	M
Basin Electric Power Cooperative	1	$757	1,661	No	M
Blue Circle Industries PLC	1	$3,295	18,637	No	M
Carmeuse Lime Inc.	18	$240	1,200	No	M
Chemical Lime Co.	19	$250	1,000	No	M
Cheney Lime & Cement Co.	2	$13	50	Yes	M
Con Lime Co.	1	$7	65	Yes	M
Cutler-Magner Co.	1	$22	75	Yes	M
Florida Crushed Stone	1	$97	600	No	M
Greer Industries	1	$150	650	No	M
Huron Lime	1	$12	35	Yes	M
McCarthy Bush Corp.	1	$69	300	Yes	M
National Lime & Stone Co.	1	$60	400	Yes	M
Pete Lien & Sons, Inc.	2	$66	350	Yes	M
Puerto Rican Cement	1	$173	1,053	No	M
Rockwell Lime	1	$11	48	Yes	M
SCANA Corporation	1	$1,650	5,488	No	M
Shen-Valley Lime Corp.	1	$2	<500	Yes	M
Southdown Inc.	1	$203	4,100	No	M
Star Group	1	$15	80	Yes	M
United States Lime & Minerals	2	$27	205	Yes	M
USG Corp	1	$36,000	143,000	No	M
Vulcan Materials	2	$2,356	9,245	No	M
Western Lime Corp	2	$17	92	Yes	M
Alcoa Inc.	1	$16,323	127,000	No	C
Amalgamated Sugar Co.	4	$250	3,000	No	C
American Crystal Sugar	5	$844	1,292	No	C
Baker Refractories	1	$15	110	Yes	C
Bowater Southern Paper Corp.	1	NA	1,225	No	C
Dow Chemical Co.	1	$18,929	39,239	No	C
Elkem Holdings Inc.	1	$400	1,300	No	C
Falco Lime	1	$35	65	Yes	C

(continued)

Table 2-6. Company-Level Data for the Lime Industry (continued)

Ultimate Parent Company Name	Number of Lime Plants	Sales ($\$10^6$)	Employment	Small Business	Type
Graymont Ltd.	6	$204	1,000	No	C,M
Imperial Sugar Co.	13	$1,889	3,800	No	C
Ispat Inland, Inc.	1	$1,075	8,200	No	C
LTV Corporation	1	$4,270	14,800	No	C
Martin Marietta Materials, Inc.	1	$6,100	1,259	No	C
Minerals Technologies Inc.	1	$638	2,236	No	C
Minn-Dak Farmers Cooperative	1	$137	480	Yes	C
Mississipi Lime	1	$90	900	No	C
Riverton Corp.	1	$14	150	Yes	C
Southern Minnesota Sugar	1	$135	500	Yes	C
Sucre Holdings	1	$76	660	Yes	C
Tate and Lyle Inc.	7	$6,326	22,000	No	C
Total	**116**	**$103,621**	**419,500**	**19**	**NA**

M = merchant
C = captive

Sources: Gale Group. 1999. *Ward's Business Directory of U.S. Private and Public Companies*. Volume 1. Detroit: Gale Group.
Seeger, Arline, National Lime Association to Tom Kelly, EPA, June 25, 2001. Correspondence.
Wood, Joe, EPA to Eric Crump, EPA, June 1, 2001. E-mail. "Summary of Total Annualized Costs (and Some Sales Figures) to Affected Small Lime Firms, With and Without PM CEMS Requirement."

operate more than one facility. Five of the captive producers operate more than a single facility.

The definition of vertical integration is somewhat more straightforward. A vertically integrated company produces inputs to be used in its own production process. A company that has undergone complete vertical integration would be involved in all stages of production from the processing of the raw materials through the distribution of the final product (Greenwald, 1984). Operators of captive supply facilities are by definition vertically integrated. They produce their own lime to be used as an input in the manufacture of a product such as beet sugar or aluminum. Commercial lime producers are generally vertically integrated as well. They own and operate limestone mines to supply kiln feed for the manufacture of lime.

Firm size, where size is defined in terms of company sales and employment, is likely to be a factor in the distribution of the impacts of the proposed NESHAP on companies. Grouping the firms by size facilitates the analysis of small business impacts as required by the RFA of 1982 as amended by SBREFA of 1996.

Firms are grouped into small and large categories using Small Business Administration (SBA) general size standard definitions based on NAICS codes. For commercial lime firms, a small company is defined as one having 500 or fewer employees. For captive supply companies that are pulp and paper producers or beet sugar manufacturers, a business with 750 or fewer employees is considered small. For captive suppliers that are steel companies, a small company is defined as one having 1,000 or fewer employees. Table 2-7 lists the employment and sales data for the small companies that are owners of lime-producing facilities. Based on the SBA definition of small business, 19 companies are small. However, seven of these companies will not be affected by this rule because they only hydrate lime or manufacture lime for use in beet sugar production.

2.4 Consumption and Uses of Lime

Many different industries use lime, but lime use generally falls into one of the following categories: agriculture, chemical and industrial (including steel production, the largest single use of lime), construction, environmental, and refractory. This section describes the consumption and uses of lime.

2.4.1 Product Characteristics

Because the quality and characteristics of lime vary considerably, consumers often use chemical and physical tests to ensure that the lime being purchased meets their requirements. The American Society for Testing and Materials (ASTM) provides specifications and tests for various uses of lime. Many of these tests are too time consuming and costly for use in routine quality control, so they are performed only occasionally. Less-involved tests of physical and chemical qualities can be done depending on the consumer's needs. Depending on the intended end use, consumers may test lime for impurities, consistency, plasticity, particle size, compressive strength, settling rate, slaking rate, and chemical composition (Boynton, 1980).

For most purposes, dolomitic and high-calcium lime can be used interchangeably. For certain purposes, however, one or the other may be preferable. For example, dolomitic

Table 2-7. Characteristics of Small Businesses in the Lime Industry

Company	Sales ($\$10^6$)	Employment
Commercial Suppliers		
Austin White Lime Co.	15	150
Cheney Lime & Cement Co.	13	50
Con Lime Co.	7	65
Cutler Magner Co.	22	75
Falco Lime, Inc.[a]	35	65
Huron Lime Co.	12	35
McCarthy Bush Corp.	69	300
National Lime & Stone Co.	60	400
Pete Lien & Sons, Inc.	66	350
Rockwell Lime Co.	11	48
Shen-Valley Lime Corp.[a]	2	<500
Star Group Corp.	15	80
United States Lime & Minerals	27	205
Western Lime Corp.	17	92
Captive Suppliers		
Baker Refractories Co.	15	110
Minn-Dak Farmers Coop.[b]	137	480
Riverton Corp.	14	150
Southern Minnesota Sugar Corp.[b]	135	500
Sucre Holding Inc.[b]	76	660

[a] These small businesses are hydrators only and are not subject to this rule.
[b] These small businesses manufacture lime for use in beet sugar production and are not subject to this rule.

Sources: Gale Group. 1999. *Ward's Business Directory of U.S. Private and Public Companies.* Volume 1. Detroit: Gale Group.
Seeger, Arline, National Lime Association to Tom Kelly, EPA, June 25, 2001. Correspondence.
Wood, Joe, EPA to Eric Crump, EPA, June 1, 2001. E-mail. "Summary of Total Annualized Costs (and Some Sales Figures) to Affected Small Lime Firms, With and Without PM CEMS Requirement."

lime is used for agricultural liming in areas where the soil is deficient in magnesium because of its higher magnesium content (Boynton, 1980).

Quicklime and hydrated lime are also interchangeable for most purposes. The choice between quicklime and hydrated lime depends on the quantity needed and the storage facilities available. Quicklime is more concentrated than hydrated lime and costs about 30 to

40 percent less per ton. However, quicklime must be stored carefully and must be slaked, or hydrated, prior to use. The consumer must weigh the cost of owning and operating slaking equipment against the savings from buying less expensive quicklime. High-volume consumers generally purchase quicklime, while smaller consumers usually buy hydrated lime (Boynton, 1980).

Almost all quicklime is shipped in bulk in covered hopper rail cars. The small quantities of quicklime that are packaged are placed in extra-heavy paper sacks. Hydrated lime is available both in bulk and packaged in multiwall, 50-pound bags. Bulk hydrate is loaded pneumatically onto tank trucks for shipment (Boynton, 1980).

2.4.2 Uses and Consumers

Table 2-8 presents data on quantities, percentages, and dollar values of lime used by various industries in 1999. Agriculture consumed less than 1 percent of lime produced in the United States. Chemical and industrial uses accounted for 64 percent of the lime consumed, with the steel industry alone consuming 30.5 percent of total lime production. Within the chemical and industrial category, other significant uses included pulp and paper production (5 percent), precipitation of calcium carbonate (6.1 percent), and sugar refining (4 percent). Construction accounted for 10.6 percent of the lime consumed, and most lime in this category is used for soil stabilization. Environmental uses for lime accounted for 23.9 percent of the market. Within this category, the largest use for lime was flue gas desulfurization (15.9 percent), followed by water purification (7.1 percent).

Table 2-9 contains information on lime use for 1998 and 1999; quantities and percentages for quicklime and hydrated lime are presented separately. For both years, the quantity of quicklime consumed was about six times greater than the quantity of hydrate consumed. The construction industry used more hydrate than quicklime, but for environmental, steel, and other purposes listed, quicklime use greatly exceeded hydrate use. All lime sold for refractory purposes was quicklime. The following section discusses some of the many uses of lime in more detail.

2.4.2.1 Agriculture

Lime is applied to fields to neutralize acid soils, offset acidity created by nitrogen fertilizers, add nutrients to the soil (calcium and magnesium), and improve soil structure. Agricultural use of lime in the United States takes place almost exclusively in the east, since western states tend to have alkaline soils (Gutschick, 1994).

Table 2-8. Quantities, Percentages, and Values for Lime by Use: 1999[a]

	1,000mt[b]	Percent	Value (10^3)
Agriculture	23	0.1	1,900
Chemical and industrial			
Glass	98	0.5	5,650
Pulp and paper	971	5.0	57,700
Precipitated calcium carbonate	1,200	6.1	71,100
Sugar refining	783	4.0	45,800
Other chemical and industrial	1,920	9.8	121,000
Metallurgical	5,000	25.5	303,000
Basic oxygen furnaces	3,930	20.1	220,000
Electric arc furnaces	1,810	10.7	107,000
Other	239	1.2	14,700
Total metallurgical	5,970	30.5	342,000
Nonferrous metals			
Aluminum and bauxite	303	1.5	17,800
Other nonferrous metallurgy	1,270	6.5	73,200
Total nonferous metallurgy	1,570	8.0	91,000
Total metallurgical	7,550	38.5	433,000
Total chemical and industrial	12,550	64.0	736,000
Construction			
Asphalt paving	362	1.8	26,500
Soil stabilization	1,280	6.5	82,700
Other	427	2.2	42,500
Total construction	2,070	10.6	152,000
Environmental			
Flue gas sulfur removal	2,750	15.9	142,000
Sewage treatment	245	1.3	15,500
Water purification	1,400	7.1	88,600
Other	297	1.5	18,600
Total environmental	4,690	23.9	265,000
Refractory lime (dead-burned dolomite)	300	1.5	24,400
Grand Total	19,600		1,180,000

[a] Numbers include commercial sales and captive supply use. Regenerated lime is not included.
[b] To convert to short tons, multiply metric tons by 1.10231.

Source: Miller, M.M. 1999b. Minerals Yearbook: Lime. Reston, VA: U.S. Department of the Interior, Geological Survey. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/index.html#myb>.

Table 2-9. Lime Sold by Producers in the United States, by Use (thousands of metric tons)[a]

Use	12 Months 1998	Percentages 1998	12 Months 1999	Percentages 1996
Quicklime				
Construction				
Soil Sabilization	795	4.0	842	4.3
General Construction	16	0.08	32	0.2
Total Construction	816	4.1	874	4.5
Refractory dolomite	300	1.5	300	1.5
Environmental	4,544	22.7	4,174	21.3
Steel, iron related	7,794	38.9	7,528	38.4
Other chemical and industrial	4,264	21.3	4,524	23.1
Total quicklime	17,718	88.4	17,400	88.7
Hydrate				
Construction				
Soil stabilization	485	2.4	438	2.2
General construction	679	3.4	758	3.9
Total construction	1,164	5.8	1,196	6.1
Environmental	576	2.9	516	2.6
Steel, iron related	46	0.02	22	1.1
Other chemical and industrial	549	2.7	476	2.4
Total hydrate	2,335	11.6	2,210	11.3
All Lime				
Total construction sales	1,980	9.9	2,070	10.6
Total refractory sales	300	1.5	300	1.5
Total environmental sales	5,120	25.5	4,690	23.9
Total steel, iron-related sales	7,840	39.1	7,550	38.5
Total chemical and industrial sales	1,950	9.7	1,920	9.8
Total sales of lime	20,053	100.0	19,610	100.0

[a] To convert metric tons to short tons, multiply metric tons by 1.10231.

Source: Miller, M.M. 1999a. Minerals Information: Lime. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390499.pdf>.

2.4.2.2 Chemical and Industrial

Lime serves many diverse and important functions in a broad range of industries. As previously mentioned, more than 60 percent of the lime consumed per year is used in chemical and industrial applications, including steel manufacturing, pulp and paper manufacturing, and sugar refining. Industries can meet their demand for lime by either purchasing lime from commercial producers or by manufacturing their own lime onsite (captive production). For example, all beet sugar producers and alkali plants operate their own lime plants to supply the large quantities of lime and carbon dioxide they require. Some steel producers, as well as manufacturers of copper, alumina, and magnesium also operate captive lime kilns (Boynton, 1980). The following section describes in more detail how a number of industries use lime.

Iron and Steel Metallurgy. Lime is used as flux in the manufacture of steel. It reacts with impurities such as phosphorus, silica, and sulfur to form slag, which is removed from the metal. The types of steel furnaces that consume lime are the basic open-hearth furnace, the basic Bessemer furnace, and the basic oxygen furnace (Boynton, 1980). The basic oxygen furnace produces about two-thirds of the steel in the United States. Electric furnaces that purify steel scrap also use lime as flux. Dead-burned dolomite is used to protect the refractory linings of open-hearth and electric furnaces and manufacture refractory brick (Gutschick, 1994).

Nonferrous Metallurgy. The production of magnesium metal or magnesia requires lime as a raw material. Lime is also used to purify nonferrous ores, including copper, gold, silver, uranium, zinc, nickel, and lead. Large quantities of lime are used in the production of alumina from bauxite (Boynton, 1980).

Sugar Refining. The beet sugar industry uses large quantities of both lime and carbon dioxide in its refining process. (Small quantities are used in the refining of cane sugar.) To meet their needs, all beet sugar manufacturers maintain their own captive lime kilns and purchase limestone to use as kiln feed, but they generally do not operate their own limestone quarries (Gutschick, 1994). Captive lime kilns only operate in the fall after the beet harvest. Manufacturers use both the lime and the CO_2 that captive lime kilns produce (Boynton, 1980).

Precipitated Calcium Carbonate (PCC). PCC is a pure white powder with uniform particle size, which is an important input in many production processes. It is used as a pigment in paint; a coating and filler for paper; a filler in rubber products; and an ingredient in putties, dentifrices, and pharmaceuticals. It is manufactured directly from lime and is also a by-product of the production of soda ash at alkali plants (Boynton, 1980).

Pulp and Paper. Quicklime is used in sulfate-process pulp plants in combination with "black liquor" (waste sodium carbonate solution), allowing sodium hydroxide (caustic soda) to be recovered. As part of this process, 92 to 98 percent of lime is also recovered. Sludge is dehydrated and pelletized, then fed through captive rotary kilns where it is calcined back into lime for reuse. Pulp plants also use lime to make calcium hypochlorite for bleaching paper and for treating wastewater (Boynton, 1980). The pulp and paper industry has been moving away from the sulfate process to an alkaline process, which produces higher quality paper at lower cost. This process still requires lime, however, in the form of PCC. As previously mentioned, PCC is used as a filler and coating material for high quality paper. Some pulp and paper manufacturers have installed PCC plants on site (Gutschick, 1994).

Other Chemical and Industrial Uses. Lime is used in the production of a number of chemicals, such as soda ash and sodium bicarbonate (alkalies), and calcium carbide. Various forms of lime are also used to produce plastics and glass. Lime is also used as a carrier for pesticides and in the production of bleaching agents. Calcium and magnesium salts such as dicalcium phosphate, magnesium chloride, and lithium salts also come from lime. Lime is used in refining food-grade salts and in producing numerous food additives (Gutschick, 1994).

2.4.2.3 Construction

The largest use of lime for construction is for soil stabilization. It is used in constructing roads, parking lots, runways, building foundations, embankments, earthen dams, railroad beds, and irrigation canal linings. When lime is added to clay soils, which contain silica, and the soil is then compacted, the lime reacts with the silica, greatly increasing the soil's stability and strength. For soils low in silica, builders use lime together with fly ash, which contains silica. Lime is also used to dry up saturated soils (Gutschick, 1994).

Lime is an important component of asphalt used for paving. It improves the asphalt's ability to adhere to the surface to which it is applied and adds to its durability (Gutschick, 1994). Lime is also used to produce building materials such as mortar, plaster, and stucco (Boynton, 1980).

2.4.2.4 Environmental

Environmental protection is a large and growing market for lime, and lime is used in various environmental applications. General descriptions of some of these uses are provided below.

Air Pollution Control. The CAA of 1970 created a new market for lime in the area of flue gas desulfurization, which has now become the second largest domestic market for lime (Miller, 1999b). Flue gas desulfurization uses lime to remove SO_2 from stack gases at utility and industrial plants that burn coal. They employ both wet and dry scrubbers. Wet scrubbers, which use slurries of lime and produce a liquid waste product, can remove up to 99 percent of SO_2 from stack gases. Dry scrubbers, which produce a dry waste, can remove sulfur with 70 to 90 percent efficiency. Lime can also be used to neutralize wastes from sulfuric acid plants, as well as other wastes such as HCl, hydrofluoric acid, and NO_x. It can also be used to scrub stack gases from incinerators and small industrial coal-fired boilers (Gutschick, 1994).

Water Treatment. Lime is used to treat potable water for softening (removing minerals), purifying (killing bacteria), and clarifying. Lime is also effective at preventing lead and copper from entering distribution systems. It does this by raising the pH of the water so that these metals remain insoluble (Gutschick, 1994).

Sewage Treatment. Lime is used to treat wastewater at sewage treatment plants. The addition of lime to wastewater causes phosphates and most heavy metals to precipitate. It also causes solid and dissolved organic compounds to coagulate and ammonia to volatilize. Lime also raises the pH to a point where bacteria, viruses, and odor are destroyed. Lime is used heavily in the treatment of sewage sludge as well. It controls odors, kills germs, and precipitates heavy metals, allowing sludge to be disposed of safely in landfills or to be used as a soil amendment (Gutschick, 1994).

Industrial Wastewater Treatment. Many industries, including the electroplating, chemical manufacturing, and textile industries, use lime to treat their wastewater. In addition, lime is used to treat effluents that are high in sulfuric acid and iron oxides from both abandoned and active coal mines (Gutschick, 1994).

2.4.3 Substitution Possibilities in Consumption

As mentioned in Section 2.4.1, the various forms of lime can often be used interchangeably. The chemical properties and composition of the lime produced relate directly to the characteristics of the limestone used as kiln feed (Gutschick, 1994). Most plants use kiln feed from an adjacent quarry, so the type of lime the plants manufacture is limited. However, commercial plants have substitution possibilities regarding the form of their final product. Lime can be sold as quicklime in various particle sizes, or it can be further processed into one of the forms of hydrated lime (Boynton, 1980). For some purposes, limestone can also be used as a substitute for lime. For example, in the flue gas desulfurization market, high purity limestone can be used instead of lime for scrubbing, and it is considerably less costly than lime. However, lime is more reactive than limestone, and the capital investment required for limestone scrubbers is higher than that for lime scrubbers. In the steel industry, basic open-hearth furnaces can use limestone instead of lime as flux. However, the basic oxygen furnace, which uses only lime as flux, has almost entirely replaced the open-hearth furnace (Gutschick, 1994). Limestone cannot replace lime for soil stabilization, but for agricultural purposes, ground limestone can be used instead of lime (Boynton, 1980).

For industrial wastewater treatment, limestone can be used to a limited extent for acid neutralization, raising pH to 6 to 6.5. However, to precipitate iron and other ferrous metals, a pH of 9 to 10 is necessary, and for this range, only lime is effective (Gutschick, 1994). Caustic soda also competes with lime in the acid neutralization market. Caustic soda is highly effective, but its price tends to be volatile (Miller, 1997).

Whiting, a type of limestone, can be used as a diluent and carrier of pesticides in lieu of hydrated lime (Gutschick, 1994). Calcined gypsum is an alternative material used in industrial plasters and mortars. Cement, lime kiln dust, and fly ash are also potential substitutes for lime in some construction uses (Miller, 1996a).

SECTION 3

REGULATORY CONTROL COSTS

EPA identified 108 lime plants in the United States and estimated the costs for each to comply with the proposed NESHAP for lime manufacturing based on model plants developed by EPA. Only about half of the lime manufacturing plants are directly affected by the rule. There are three primary reasons why many plants will not be directly affected. First, captive lime plants producing lime for use in pulp and paper production or in sugar production are exempt from this rule (25 plants). Second, plants that are hydrating plants only will not be subject to the rule because they do not have any kilns (11 plants). Finally, only the approximately 70 percent of kilns located at major sources are subject to controls.[1] This section includes the costs of air pollution controls and testing and monitoring requirements for new and existing lime kilns, lime coolers, and materials handling operations (MHO). Control costs have been estimated for kiln models and on a plant-wide basis for MHO. The HAPs of concern for the kilns and MHO are PM/metals.

All facilities that manufacture lime operate some type of kiln.[2] The kiln converts limestone into lime through heating, a process known as calcination. When limestone is subjected to high temperatures, it undergoes a chemical decomposition resulting in the formation of lime (CaO) and the emission of CO_2.

Emissions in lime production facilities occur from the following general sources:

- kiln (90 percent of PM emissions),
- coolers, and
- MHO.

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[1]All nonexempt plants (i.e., those not dedicated exclusively to the production of lime for use in beet sugar or pulp and paper production) will incur costs associated with an HCl test using the American Society for Testing and Materials (ASTM) standard method to verify whether they are major sources. However, only those kilns located at major sources will incur further compliance costs to add controls under this NESHAP.

[2]There are lime plants that are hydrators only. These plants do not have kilns, but generally purchase quicklime from other producers and hydrate it prior to commercial sale.

As described in this section, the Agency estimated the compliance costs for each facility to install the necessary equipment and process controls that will reduce emissions and bring each facility into compliance with the NESHAP. The estimation of these costs is applied to existing facilities using a baseline year of 1997. The remainder of this section describes the model plants used in the analysis and the annual control costs. The annual control costs serve as an input into the economic model. For each of the affected lime plants owned by a small business, compliance costs specific to that plant were developed. Absent engineering determination of kiln-specific applicability of controls, a computer model randomly determines which controls each kiln owned by a large company faces based on rates of applicability determined by the engineering analysis. The model estimates the impact variables through multiple simulations given different random assignments of applicability. The Agency conducted 35 independent simulations and averaged across those simulations to provide a measure of the total compliance costs expected to fall on large firms.

3.1 Model Plants

The large number of lime kilns in the United States necessitates using model kilns to simulate the effects of applying the regulatory controls to this industry. A model kiln does not represent any single actual kiln. Instead, it represents a range of kilns with similar characteristics that may be affected by the regulation. Model kilns for the existing lime kilns were based on data provided in questionnaire responses from 55 lime manufacturing plants. These responses represent 81 percent (55/68) of the commercial lime manufacturing plants in the United States at the time of the survey. The models were constructed by grouping kilns by type (e.g., rotary, vertical) and then by annual design production capacity (RTI, 1996).

Table 3-1 summarizes the characteristics for each model kiln as well as the number of actual kilns in the United States assigned by EPA to each model type. Thirteen model kilns, designated A through M, are provided for existing kilns (RTI, 1996). Five of these model kilns (A, J, K, L, M) are being considered confidential business information (CBI) because summary information about these models would allow identification of individual plant information that the plants deem confidential. Additional models N, P, Q, and R were

developed for new kilns (RTI, 1997).[3] These model kilns serve as the basis for estimating the compliance costs associated with the MACT standards proposed under the authority of the CAA.

3.2 Control Costs

The remainder of this section describes the controls based on plant characteristics and then summarizes their associated costs. Sources of HAP emissions in lime production include the lime kiln, cooler, and MHO. Based on the engineering analysis, the MACT floor for existing major sources is defined to include upgrading PM controls, cooler controls, and MHO, and complying with testing and monitoring requirements. However, due to a provision in the rule to allow bubbling of PM emissions from the kilns and coolers and the small percentage of coolers (4 percent) expected to have needed upgrades even without bubbling, EPA assumes the costs of cooler PM controls are zero. Area sources would not incur any costs, except the costs to measure HCl to determine major source status (EPA, 2002).

3.2.1 Particulate Matter Controls

Control costs have been estimated for major sources to upgrade their current fabric filters or electrostatic precipitators to control PM at the kilns. For major sources with wet scrubbers, costs were estimated based on these kilns upgrading their existing wet scrubbers with Venturi scrubbers. In addition, some kilns are uncontrolled (or use gravel bed filters or cyclones). For these kilns, costs were estimated for them to install fabric filters. Costs were also estimated for all new kilns to install fabric filters. Tables 3-2 through 3-6 summarize the costs for each of the categories that must improve their PM controls. Table 3-2 provides the estimated annual costs associated with upgrading existing fabric filters with new filter bags for each model plant. Table 3-3 furnishes the estimated annual costs of upgrading existing wet scrubbers with a new Venturi scrubber. Table 3-4 presents the estimated annual costs of installing a new fabric filter on an uncontrolled kiln. Table 3-5 summarizes the estimated annual costs associated with adding an additional field to existing ESPs. Finally, Table 3-6 provides the estimated annual costs of installing a new fabric filter on a new kiln. Costs in each table are only provided for model plants where corresponding plants with the specified

[3] A model "O" plant was also developed in this memorandum but was dropped from subsequent analysis because it was later concluded that no plants of that model type were likely to be built in the near future.

Table 3-2. Annual Costs of Upgrading Existing Fabric Filter with New Bags Throughout (1997$)

Model Kiln ID	Total Capital Investment ($\$10^3$)	Annualized Capital Cost ($\$10^3$)	Direct Annual Cost ($\$10^3$)	Indirect Annual Cost ($\$10^3$)	Total Annual Cost[a,b,c] ($\$10^3$)
A	22	6	19	11	36
B	16	5	19	11	35
C	37	11	19	11	41
D	51	15	20	11	46
E	73	22	21	11	54
F	112	33	23	11	67
G	19	6	19	11	36
H	35	10	20	11	42
I	52	15	21	11	48
K	5	2	19	11	31
L	23	7	20	11	38

Notes:
[a] Total Annual Costs = Annualized Capital Cost + Direct Annual Cost + Indirect Annual Cost.
[b] Individual costs are rounded to the nearest thousand dollars and may not sum to the totals shown above.
[c] EPA expects that 29 percent of kilns with fabric filters will not meet the PM emissions limit and those located at major sources will incur these costs.

Source: U.S. Environmental Protection Agency (EPA). November 6, 2002. Memorandum from James Crowder, EPA, to Ron Evans, EPA. Cost inputs for economic impacts analysis for the lime industry NESHAP.

pollution control device exist and only apply to kilns located at major sources not meeting the emissions standards.

For each current air pollution control device (APCD), EPA calculated the percentage of existing kilns at major sources that are expected to require an upgrade (EPA, 2002). For the 70 percent of existing lime plants that are expected to be major sources, EPA estimated that 29 percent of kilns with fabric filters, 33 percent of those with electrostatic precipitators, 90 percent of those with wet scrubbers, and 100 percent of uncontrolled lime kilns will incur costs to upgrade or replace their APCD systems because they will not meet emissions standards under the proposed NESHAP.

Table 3-3. Annual Costs of Upgrading Existing Wet Scrubber (1997$)

Model Kiln ID	Total Capital Investment ($$10^3$)	Annualized Capital Cost ($$10^3$)	Direct Annual Cost ($$10^3$)	Indirect Annual Cost ($$10^3$)	Total Annual Cost[a,b,c] ($$10^3$)
A	252	28	75	11	113
B	288	32	88	11	131
C	520	57	220	16	293
D	663	73	312	19	403
G	301	33	102	12	146
H	499	55	207	15	278
I	682	75	326	19	420
L	351	39	129	13	180
M	177	19	36	9	64

Notes:

[a] Total Annual Costs = Annualized Capital Cost + Direct Annual Cost + Indirect Annual Cost.

[b] Individual costs are rounded to the nearest thousand dollars and may not sum to the totals shown above.

[c] EPA expects that 90 percent of kilns with scrubbers will not meet the PM emissions limit and those located at major sources will incur these costs.

Source: U.S. Environmental Protection Agency (EPA). November 6, 2002. Memorandum from James Crowder, EPA, to Ron Evans, EPA. Cost inputs for economic impacts analysis for the lime industry NESHAP.

3.2.2 Cooler Controls

The Agency estimated that 4 percent of lime plants have coolers that exhaust directly to the atmosphere uncontrolled, which may have to be controlled to meet emissions limits. However, as mentioned earlier, the proposed rule includes a provision for bubbling of PM emissions from kilns and coolers. EPA assumes that the incremental costs associated with cooler PM controls are zero because of the small number of kilns with uncontrolled coolers and the fact that these plants are expected to meet their bubbled emissions limits without cooler controls.

Table 3-4. Annual Costs of Installing a New Fabric Filter on an Existing Uncontrolled Kiln (1997$)

Model Kiln ID	Total Capital Investment ($\$10^3$)	Annualized Capital Cost ($\$10^3$)	Direct Annual Cost ($\$10^3$)	Indirect Annual Cost ($\$10^3$)	Total Annual Cost[a,b,c] ($\$10^3$)
B	505	48	257	44	348
C	1,037	98	570	55	723
D	2,301	217	753	80	1,050
E	3,529	333	1,153	104	1,590
F	5,797	547	1,988	150	2,685
G	558	53	437	45	534
H	984	93	860	54	1,006
I	2,395	226	1,283	82	1,591
J	207	20	89	38	147

Notes:

[a] Total Annual Costs = Annualized Capital Cost + Direct Annual Cost + Indirect Annual Cost.

[b] Individual costs are rounded to the nearest thousand dollars and may not sum to the totals shown above.

[c] EPA expects that 100 percent of the uncontrolled kilns (including those with cyclone or gravel bed filters) will not meet the PM emissions limit and will incur these costs if located at a major source.

Source: U.S. Environmental Protection Agency (EPA). November 6, 2002. Memorandum from James Crowder, EPA, to Ron Evans, EPA. Cost inputs for economic impacts analysis for the lime industry NESHAP.

3.2.3 Materials Handling Operations Control Costs

EPA calculated control costs for improving the MHO at each major source at the plant level. The Agency estimated that each major source will incur a $68,600 annual cost to control their MHO with fabric filters (EPA, 2002).

3.2.4 Testing and Monitoring Costs

Kilns and MHO will be subject to testing and monitoring costs. Testing and monitoring costs for kilns would be incurred only at major sources, except that the HCl tests would be incurred by every plant to test whether they are a major source. Table 3-7 provides the costs for testing and monitoring of the kilns at a plant. Note that the costs for testing additional kilns at the same plant are lower than the cost of testing the first kiln. Although

Table 3-5. Annual Costs Associated with Adding an Additional Field for Existing Electrostatic Precipitators (ESP) (1997$)

Model Kiln ID	Total Capital Investment ($\$10^3$)	Annualized Capital Cost ($\$10^3$)	Direct Annual Cost ($\$10^3$)	Indirect Annual Cost ($\$10^3$)	Total Annual Cost[a,b,c] ($\$10^3$)
C	1,136	107	22	51	181
D	1,426	135	29	64	227
G	676	64	14	32	109

Notes:
[a] Total Annual Costs = Annualized Capital Cost + Direct Annual Cost + Indirect Annual Cost.
[b] Individual costs are rounded to the nearest thousand dollars and may not sum to the totals shown above.
[c] EPA expects that 33 percent of kilns with ESPs will not meet the PM emissions limit and those located at major sources will incur these costs.
Source: U.S. Environmental Protection Agency (EPA). November 6, 2002. Memorandum from James Crowder, EPA, to Ron Evans, EPA. Cost inputs for economic impacts analysis for the lime industry NESHAP.

Table 3-6. Annual Costs of Installing a New Fabric Filter on a New Kiln (1997$)

Model Kiln ID	Total Capital Investment ($\$10^3$)	Annualized Capital Cost ($\$10^3$)	Direct Annual Cost ($\$10^3$)[a]	Indirect Annual Cost ($\$10^3$)	Total Annual Cost[b,c,d] ($\$10^3$)
N	565	54	–3	17	67
P	668	63	–4	19	78
Q	925	88	–8	24	103
R	589	56	111	46	213

Notes:
[a] Negative direct annual costs reflect savings due to reduced electricity consumption because of a larger baghouse with less pressure drop.
[b] Total Annual Costs = Annualized Capital Cost + Direct Annual Cost + Indirect Annual Cost.
[c] Individual costs are rounded to the nearest thousand dollars and may not sum to the totals shown above.
[d] All new kilns are expected to incur these costs.
Source: U.S. Environmental Protection Agency (EPA). November 6, 2002. Memorandum from James Crowder, EPA, to Ron Evans, EPA. Cost inputs for economic impacts analysis for the lime industry NESHAP.

Table 3-7. Kiln Testing and Monitoring Costs[a] (1997$)

Test Method or Monitoring Requirement	Total Capital Cost ($)	One Time Cost ($)	Total Annualized Cost ($)[b]
Method 5		10,000[c]	2,500
HCl test (ASTM method)		9,500[d]	2,400
Bag leak detector single stack control device[e]	10,600		3,300
Bag leak detector for multi-stack control device[e]	39,000		8,000
Costs for the start-up, shut-down, and malfunction plan; the operations, maintenance, and monitoring plan; and other miscellaneous requirements			10,000
PM CEMS[f]	192,000		21,000

Notes:

[a] These costs will be incurred only at major sources, except for the costs associated with an HCl test, which will be incurred by every plant to verify major source status.

[b] One-time costs are annualized over a 5-year period using a 7 percent interest rate.

[c] Add $5,000 (one-time cost) for each kiln tested at same location ($1,250 annualized cost).

[d] Add $3,100 (one-time cost) for each kiln tested at same location ($775 annualized cost).

[e] Applies only to kilns with fabric filters (including those kilns that will install fabric filters to comply with the PM emissions limits). However, it was assumed that all kilns will use bag leak detectors for costing purposes. It was assumed that 55 percent of existing kilns with baghouses or scrubbers and 34 percent of kilns with ESPs will install multi-stack control devices and the remainder will install single stack devices.

[f] One option for this regulation would be to require continuous emissions monitoring systems (EMS) for PM emissions for those kilns with single stack control devices. Under this option, kilns with single stack control devices would incur PM CEMS costs instead of bag leak detector costs.

Source: U.S. Environmental Protection Agency (EPA). November 6, 2002. Memorandum from James Crowder, EPA, to Ron Evans, EPA. Cost inputs for economic impacts analysis for the lime industry NESHAP.

the cost associated with installing a bag leak detector should only be incurred by those kilns that have fabric filters or that switch to fabric filters to meet PM requirements, it was assumed that all kilns located at major sources would incur these costs for regulatory costing purposes.[4]

Testing and monitoring for MHO is assumed to require $15,000 in one-time costs for PM tests, which is an annualized cost of $3,750.[5] In addition, the Agency estimated that 95 percent of major source plants will incur $5,600 for annual monitoring costs, while 5 percent of major sources will incur $12,600 for annual monitoring costs (EPA, 2002).[6]

3.3 Total Annual Control Costs

EPA estimated the total annual compliance cost of this rule to existing lime manufacturing plants in the absence of market adjustments to be $22.4 million without PM CEMS and $23.3 million for the option requiring PM CEMS for single stack control devices. These estimates are based on the plant-specific costs estimated for small businesses and the national proportion of lime kilns and plants expected to receive each of the costs included in this section for plants owned by large businesses. EPA completed multiple simulations of a cost estimation model to derive average control costs at the plant level for plants owned by large companies. This average cost for large companies was added to the plant-specific costs available for small businesses to generate the total costs entering the economic model. Table 3-8 summarizes the compliance cost inputs used for the economic model.

[4]Recall that all uncontrolled kilns at major sources are expected to install fabric filters to comply with this MACT. Those kilns that install fabric filters will also need to install bag leak detectors to help ensure that their control devices are working properly.

[5]This cost was annualized over 5 years.

[6]The discrepancy in annual monitoring costs results because most plants will only have to test annually (and will incur the lower monitoring costs), but those plants that fail to meet the PM requirements in their annual test will subsequently be required to perform monitoring monthly (and will incur the higher monitoring costs). For costing purposes, all small businesses were assumed to incur the higher costs associated with monthly monitoring.

Table 3-8. National Engineering Control Cost Estimates

	Without PM CEMS	With PM CEMS
Capital Cost ($\$10^6$)		
Large Firms	24.2	31.8
Small Firms	11.9	16.8
Total Capital Cost	36.1	48.6
Annual Compliance Cost ($\$10^6$)[a]		
Large Firms	15.6	16.0
Small Firms	6.8	7.3
Total Annual Compliance Cost	22.4	23.3
Annual Compliance Cost Per Metric Ton of Lime ($/ton)		
Large Firms[b]	1.04	1.07
Small Firms[b]	2.55	2.73
Overall Annual Compliance Cost Per Metric Ton	1.16	1.22

[a] The annual compliance cost estimates include annualized capital costs as well as ongoing costs resulting from the rule.

[b] These values were calculated based on market production only because no information was available breaking captive production into small and large firms.

SECTION 4

ECONOMIC IMPACT ANALYSIS: METHODS AND RESULTS

The proposed MACT requires lime manufacturers to meet emission standards for the release of HAPs into the environment. To meet these standards, companies will have to add or update PM control devices and add controls to reduce emissions from their materials handling operations for kilns located at major sources. These changes result in higher costs of production for the affected producers and have additional welfare implications when these costs are transmitted through market relationships. This section describes and quantifies the changes in economic welfare required to achieve environmental improvements.

EPA developed measures of the size and distribution of economic impacts by comparing baseline conditions in the 1997 national lime market with those expected to result from implementing the proposed MACT. The main elements of this section include the following:

- brief overview of the conceptual approach to estimating impacts as well as a discussion of the EIA data inputs used to develop a spreadsheet model, and
- presentation and interpretation of economic estimates projected by the economic model including
  - market-level impacts (e.g., changes in price, domestic production, and imports),
  - industry-level impacts (e.g., changes in revenue, costs, closures, and employment), and
  - societal-level impacts (e.g., estimates of the consumer burden as a result of higher prices and reduced consumption levels and changes in domestic and foreign profitability).

4.1 EIA Methodology Summary

EPA developed this methodology using standard microeconomic theory. We rely heavily on previous economic analyses, employing a comparative static approach, and assume certainty in relevant markets. We also assume prices and quantities are determined in a perfectly competitive market for a single lime commodity as shown in Figure 4-1(a) determined by the intersection of market supply and demand curves. Under the baseline scenario, a market price and quantity (P, Q) are determined by the downward-sloping market demand curve (D^M) and the upward-sloping market supply curve (S^M) that reflects the horizontal summation of the individual supply curves of directly affected and indirectly affected facilities that produce a given product.

With the regulation, the cost of production increases for directly affected producers. The imposition of the compliance costs is represented as an upward shift in the supply curve for each affected facility from S_a to S_a . As a result, the market supply curve shifts upward to S^M as shown in Figure 4-1(b) reflecting the increased costs of production at these facilities. In the baseline scenario without the proposed standards, the industry would produce total output, Q, at the price, P, with affected facilities producing the amount q_a and unaffected facilities accounting for Q minus q_a, or q_u. At the new equilibrium with the regulation, the market price increases from P to P , and market output (as determined from the market demand curve, D^M) declines from Q to Q . This reduction in market output is the net result from reductions at affected facilities and increases at unaffected facilities.

4.2 Operational Model

To develop quantitative estimates of economic impacts, the Agency developed an operational model using spreadsheet software. As described below and in more detail in Appendix A, this model characterizes baseline supply and demand and the behavioral responses to changes in costs and/or market prices.

4.2.1 Market Supply

EPA defined market supply in the lime market as the sum of domestic and foreign supply. Domestic supply is the sum of baseline quantities supplied by commercial lime plants within the market. Given the uncertainty of plant-specific costs and the limited production data for large firms, we modeled one aggregate domestic producer owned by large firms, one aggregate foreign producer using import data reported by USGS, and 14 plant-level producers owned by small firms (see Appendix A for details). Each supply function's parameters were calibrated using baseline production, price data, and the responsiveness of supply to changes in price (supply elasticity). In the absence of available empirical estimates, the domestic supply elasticity was assumed to be 1. Empirical estimates for the foreign supply elasticity (7.0) were available for a similar commodity, Portland

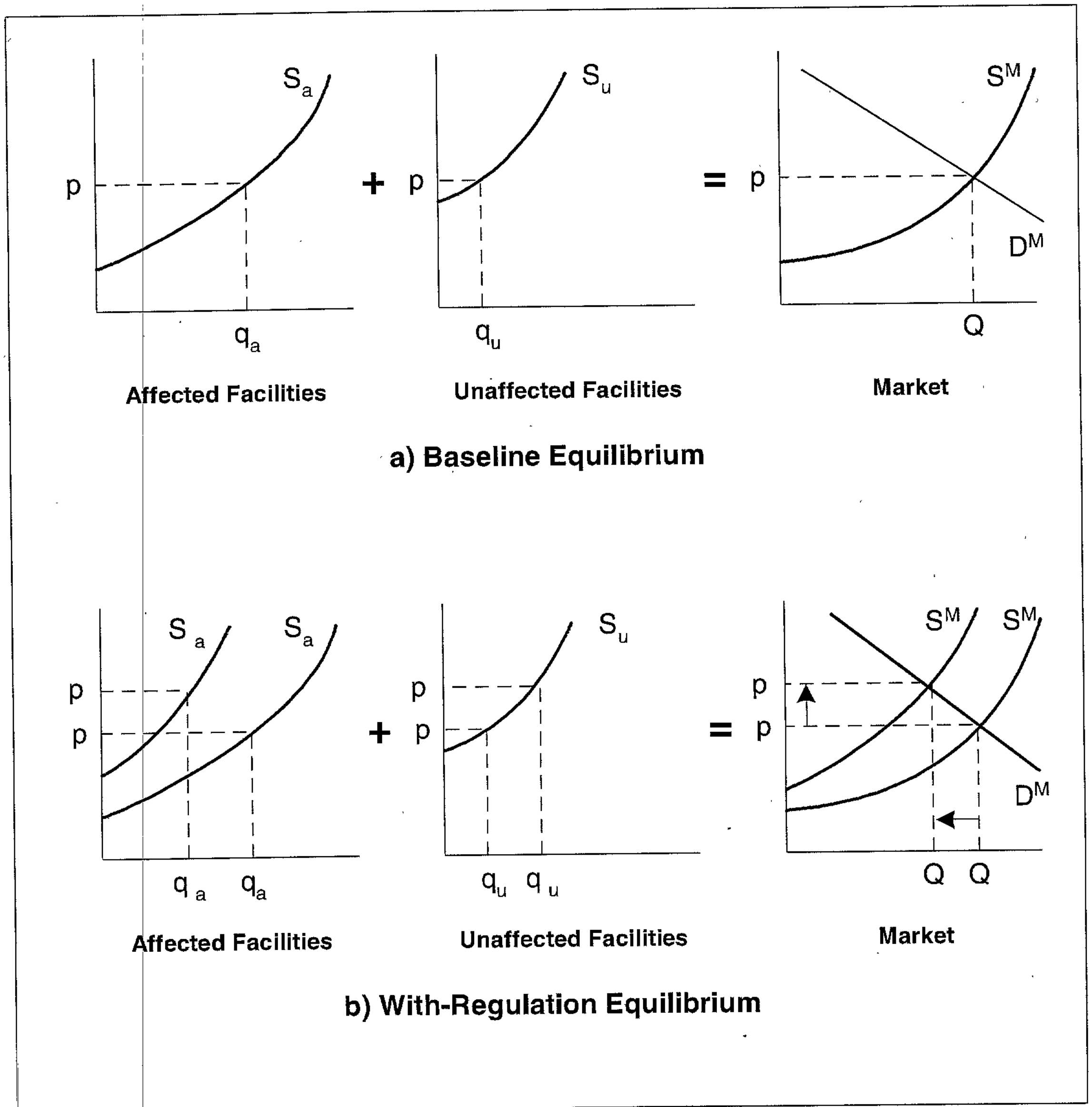

Figure 4-1. Market Equilibrium without and with Regulation

cement (EPA, 1999a), and it was assumed that the foreign supply elasticity for quicklime was the same as for cement. To examine the sensitivity of the results to these assumptions, results were also estimated for both larger and smaller supply elasticities. These results are presented in Appendix B.

4.2.2 Market Demand

The Agency modeled two aggregate consumers (domestic and foreign) in the lime market with downward-sloping demand curves consistent with the theory of demand. The Agency constructed demand functions for both domestic and foreign consumers using baseline quantity and price data and assumptions about the responsiveness of the quantity demanded to changes in price (demand elasticity). Empirical estimates for demand elasticities were available for a similar commodity, Portland cement, and for aggregate commodity groups such as stone, clay and glass. An empirical estimate of the domestic demand elasticity for Portland cement of –0.9 (EPA, 1999a) was assumed to apply to the domestic demand for lime as well because of the similarity of these products.[1] Ho and Jorgenson (1998) report an export demand elasticity of –1.2 for the stone, clay and glass industry, which was assumed to apply to lime, as well. In addition, a sensitivity analysis was conducted to examine the influence of the demand elasticity assumptions on the results of the market model. These results are presented in Appendix B.

4.2.3 Control Cost Inputs and With-Regulation Equilibrium

As described in Section 3, the Agency developed compliance cost estimates for model kilns based on current controls and other kiln characteristics. To serve as inputs to the analysis, the model kilns and associated compliance costs for each category of control are mapped to actual kilns in the economic model. The total annual compliance costs are expressed per unit of output and serve as "cost-shifters" of the kiln-level supply functions described above. For kilns located at plants owned by small commercial firms, EPA estimated kiln-specific costs and aggregated across the kilns located at each plant to get plant-specific compliance costs. However, there were insufficient resources to estimate plant-level costs for plants owned by large companies. Absent engineering determination of kiln-specific applicability of controls, the computer model randomly determines which controls each kiln owned by a large company faces based on rates of applicability determined by the engineering analysis. The model estimates the impact variables through

[1]In addition, several versions of an econometric model of the demand for lime were estimated to verify the choice of demand elasticity and the results supported the use of –0.9 as the demand elasticity for lime.

multiple simulations given different random assignments of applicability.[2] The Agency conducted 35 independent simulations and averaged across those simulations to provide a measure of the total compliance costs expected to fall on large firms. There is uncertainty about the actual outcome for a given kiln because of the uncertainty associated with the applicability of compliance costs. In each simulation, a given kiln either receives each type of control costs or not based on the probability of the kiln getting that cost. The average results across all simulations will then be a measure of the average outcome, but the actual outcome for a given kiln will differ from this average because in actuality, each kiln will either get all of the costs associated with a particular control or none of them. They will not actually get costs equal to the average cost. Thus, rather than modeling individual kilns or plants for large firms, EPA applied the average total compliance costs falling on large firms as estimated in the simulation model to a single aggregate supplier representing all large firms. Although there is a great deal of uncertainty about whether an individual kiln will incur compliance costs, the total costs borne by all large firms can be estimated fairly accurately based on the percentage of the total population expected to incur each type of compliance cost.

4.3 Economic Impact Results

The theory presented above suggests that producers attempt to mitigate the impacts of higher-cost production by shifting the burden on to other economic agents to the extent the market conditions allow. We would expect the model to project upward pressure on prices for lime as producers reduced domestic output rates in response to higher costs. Unaffected foreign production (imports) would increase in response to higher prices. Consumption rates (domestic and exports) would be expected to fall. These interacting market adjustments determine the social costs of the regulation and its distribution across stakeholders (producers and consumers).

4.3.1 National Market-Level Impacts

The increased cost of production due to the regulation is expected to increase the price of lime and reduce production/consumption from baseline levels. As shown in Table 4-1, the price of lime increases 2.1 percent in the without PM CEMS control cost scenario. Production by small firms declines by 373,000 metric tons (Mt) and large firm production increases by 34,000 Mt, for a net decline in domestic production of 339,000 Mt,

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[2]A kiln is affected by the control if the random number indicator (R_i) is less than or equal to the applicability percentage (N%). Additional information on controls and applicability are presented in Section 3.

Table 4-1. National-Level Market Impacts of the Proposed Lime Manufacturing MACT: 1997

		Without PM CEMS		With PM CEMS	
		Change		Change	
	Baseline	Absolute	Relative	Absolute	Relative
Price ($/metric ton)	$56.60	$1.17	2.1%	$1.20	2.1%
Quantity (metric tons/yr)	16,937,000	–310,146	–1.8%	–317,347	–1.9%
Domestic	16,751,000	–338,867	–2.0%	–346,792	–2.1%
Large	14,098,690	34,243	0.2%	31,447	0.2%
Small	2,652,310	–373,110	–14.1%	–378,239	–14.3%
Imports	186,000	28,721	15.4%	29,445	15.8%

or 2.0 percent. Imports increase by 29,000 Mt, or 15.4 percent, resulting in a net decline in the quantity of lime available of 310,000 Mt (1.8 percent). Similar impacts are projected in the with PM CEMS control cost scenario. The price of lime increases 2.1 percent and domestic production of lime declines by 347,000 Mt, or 2.1 percent. Imports increase by 29,000 Mt, or 15.8 percent, resulting in a net decline in the quantity of lime available of 317,000 Mt (1.9 percent).

4.3.2 National Industry-Level Impacts

Revenue, costs, and profitability of the directly affected industry also change as prices and production levels adjust to increased costs associated with compliance. For domestic lime producers, pre-tax earnings are projected to decrease by $0.8 million in the without PM CEMS control cost scenario (see Table 4-2). These losses are the net result of three effects:

Increased revenue ($0.1 million)—small revenue increases resulting from increases in the price of lime are offset by reductions in revenue resulting from output declines.[3]

[3]The fact that the estimated change in revenue is almost exactly equal to zero is driven by the assumption that the supply elasticity is equal to one. Given this elasticity, equilibrium price and quantity change by the same percentage in opposite directions, leaving total industry revenue essentially unchanged. Alternative versions of the model were estimated with different supply elasticities. The quantitative results differ somewhat depending on the elasticities chosen, but the major qualitative implications are very similar across models.

Table 4-2. National-Level Industry Impacts of the Proposed Lime Manufacturing MACT: 1997

[redacted]

NA = Not available.
[a]Estimate of control costs after market adjustments.
[b]Change in pre-tax earnings is equal to the engineering cost estimate.

Reductions in production costs as output declines ($18.0 million)—production costs fall as firms reduce their output.

Increased control costs ($18.0 million)—we have assumed total annual compliance costs vary with the level of output. Therefore, the compliance costs being incurred with regulation are smaller than the engineering compliance costs input into the model ($22.4 million) because output declines due to regulatory costs.

The national-level results also provide insight into distributional impacts of the rule among different producers. Small firm pre-tax earnings are projected to decline by $1.9 million, or 22.1 percent, while large firms experience a $1.9 million increase in pre-tax earnings (3.5 percent). Captive firms have reductions in earnings of $0.8 million (based on the assumption that they absorb all compliance costs they incur). In contrast, foreign producers gain approximately $0.2 million as they benefit from higher lime prices but do not incur compliance costs.

In the with PM CEMS cost scenario, domestic lime producer pre-tax earnings are projected to decrease by $1.3 million. The distributional impacts in this cost scenario are similar to those for the case without PM CEMS described above. Pre-tax earnings of small firms are projected to decline by $2.2 million, or 25.5 percent. Large firms experience an increase in pre-tax earnings of $1.8 million (3.2 percent) and captive firms' reduction in pre-tax earnings is $0.9 million (based on the assumption that they absorb all compliance costs they incur). In contrast, foreign producers gain approximately $0.2 million as they benefit from higher lime prices.

Although the economic analysis to this point projects a net decline in small commercial plant pre-tax earnings, we want to emphasize this result should not be interpreted to suggest all of these plants experience profit losses. As shown in Table 4-3, several plants will become more profitable under both alternatives (i.e., 6 plants both with and without PM CEMS). These plants have lower average per-unit compliance costs ($0.63 and $0.76 per metric ton) than plants that become less profitable or close (>$2.00 per metric ton).

4.3.3 Closure Estimates

Plant-level control cost and production data were available for small firms and the Agency modeled plant-level supply decisions and closure decisions for these plants (see Appendix A). Unfortunately, supply from large firms could only be characterized by an aggregate producer because of limited data and the uncertainty surrounding plant-specific

compliance costs. Therefore, we limited the assessment of potential for closures to small commercial lime plants. For these plants, the Agency evaluated the economic impacts of the rule using two different assumptions regarding firm choices and market feedbacks. These assumptions and the results of the analysis are described below.

The first approach assumes affected producers have very limited choices and cannot adjust production rates in response to higher production costs. They fully absorb these costs resulting in a one-to-one reduction in pre-tax earnings. If the additional compliance costs associated with the rule reduce a plants' pre-tax earnings below zero, the lime producer ceases their operations. The Agency developed quantitative estimates of closure impacts under this assumption by computing the ratio of annual compliance costs to baseline lime revenue and comparing these ratios to the average industry profit margin of 5.7 percent. As shown in Table 4-4, two small commercial lime plants have ratios exceeding 5 percent, and thus may potentially close under both alternatives.

The second approach relaxes the constraint on producer choices and assumes producers and consumers adjust production/consumption levels to new optimal rates consistent with changes in production costs and market prices. Just as for the full-cost absorption scenarios described above, the closure criteria used are based on whether pre-tax earnings are projected to be positive or negative after regulation. The economic analysis concludes that two of the 14 plants owned by small firms may close under scenarios both with and without PM CEMS, which is the same conclusion reached using a full-cost absorption assumption. The average control costs for these plants are \$9.26 and \$9.61 per metric ton of lime for cost scenarios without and with PM CEMS, respectively. The average cost-to-sales ratio for these plants is far higher than the average profit ratio reported for the industry (>8 percent for both cost scenarios). Although the estimated increase in market price would enable the plants to pass some of the costs on to consumers, those two plants are still expected to have negative pre-tax earnings if they were to comply with the regulation. Therefore, the Agency expects that these plants would choose to cease operations rather than comply.

Estimates of plant closures are sensitive to the accuracy of the baseline characterization of these entities (i.e., revenue and costs of production, and costs of compliance with the rule). Although the Agency employed the best data available, we acknowledge critical parameters for these analyses are based on industry-level accounting data (i.e., profit rates) and/or assumed values (i.e., supply elasticity). These limitations

should be considered when interpreting the results. Appendix B contains a sensitivity analysis showing the effects of varying key parameters on the results.

4.3.4 Employment Impacts

Reduction in domestic production leads to changes in industry employment. These changes were estimated by multiplying the change in domestic production by census data on industry employment:

$$E_1 = \left[\ \ Q / Q\right] \bullet E_0 \tag{4.2}$$

Domestic employment is projected to decline by 98 employees (full-time equivalents [FTEs] without PM CEMS and 100 employees with PM CEMS.

4.3.5 Social Costs

The value of a regulatory action is traditionally measured by the change in economic welfare that it generates. The regulation's welfare impacts, or the social costs required to achieve environmental improvements, will extend to consumers and producers alike. Consumers experience welfare impacts due to changes in market prices and consumption levels associated with the rule. Producers experience welfare impacts resulting from changes in pre-tax earnings corresponding with the changes in production levels and market prices. However, it is important to emphasize that this measure does not include benefits that occur outside the market, that is, the value of reduced levels of air pollution with the regulation.

The economic analysis accounts for behavioral responses by producers and consumers to the regulation (i.e., shifting costs to other economic agents). This approach provides insights into the way in which the regulatory burden is distributed across stakeholders. As shown in Table 4-5, the economic model estimates the total social cost of the rule of $20.2 million in the without PM CEMS. As a result of higher prices and lower consumption levels, consumers (domestic and foreign) are projected to lose $19.7 million. Domestic producer surplus declines by $0.8 million. Foreign producers unambiguously gain as a result of the regulation with profit increasing by $0.2 million. These foreign producers benefit from the higher prices associated with additional control costs on domestic producers and the fact that they do not have to incur the costs.

Table 4-5. Distribution of Social Costs Associated with the Proposed Lime Manufacturing MACT ($\$10^6$/yr)

[redacted]

[a] Assumed to be equal to the engineering cost estimates.

Similar impacts occur with PM CEMS controls, although the burden is a bit higher for both consumers and producers in this scenario. The economic analysis estimates the total social cost of the rule to be \$21.2 million. Consumers (domestic and foreign) are projected to lose \$20.1 million and domestic producer surplus declines by \$1.3 million. Foreign producers gain as a result of the regulation with profit increasing by \$0.2 million.

In both scenarios estimated, the majority of costs are passed on to consumers. This is due in part to the elasticities used, but is also being caused by the projected facility closure. The result of the firm closures is an increase in price for all remaining firms that more than offsets the loss in earnings for the firms that shut down, at least for the range of this analysis.

4.4 Energy Impacts

EO 13211, "Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use" (66 Fed. Reg. 28355, May 22, 2001), requires federal agencies to estimate the energy impact of significant regulatory actions. Thus, a screening analysis was conducted to determine the magnitude of the proposed rule's impact on energy consumption. In this analysis, we provide quantitative estimates of the projected changes in energy use due to

- expected changes in the pollution abatement equipment used in the lime manufacturing industry (e.g., substitution of fabric filters for wet scrubbers) and
- declines in lime production due to the increased costs of production.

These impacts are then compared with thresholds used to define "significant energy actions" under EO 13211.

4.4.1 Changes in Lime Manufacturing Energy Consumption

To assess the potential energy impacts associated with the proposed rule, baseline energy consumption data reported by the 1994 Manufacturing Energy Consumption Survey (DOE, 1999) were collected for the lime industry (SIC 3274).[4] As shown in Table 4-7, the lime industry uses approximately 66.15 kWh of electricity, 0.02 barrels of petroleum, 689.67 cubic feet of natural gas, and 0.19 metric tons of coal and coke per metric ton of lime. The economic model described in Section 4.2 projects a decline in annual domestic lime production of approximately 340,000 metric tons in the cost scenario without PM CEMS and 347,000 metric tons in the cost scenario with PM CEMS. Based on these projected reductions in lime production and the values for average energy use per metric ton of lime provided in Table 4-6, EPA estimated the change in energy use expected to result from the lime manufacturing NESHAP.

In addition to the reductions in energy use implied by declines in lime output, the proposed rule is expected to increase electricity consumption due to changes in air pollution controls on lime kilns. Existing sources are likely to replace existing wet scrubbers with Venturi wet scrubbers to comply with the rule. Engineering analysis suggests electricity use by existing sources would increase by 7.2 million kWh per year under the proposed rule due to this substitution between types of wet scrubbers. New sources are projected to consume an additional 0.066 million kWh per year under the regulation.

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[4]The Energy Information Administration recently published 1998 survey data. However, the available consumption data for 1998 are not sufficiently disaggregated to identify usage specific to the lime industry.

Table 4-6. Energy Usage in the Lime Manufacturing Industry (1994)

Industrial Sector	Energy Usage	Energy Use per Metric Ton of Lime Produced[a]
Electricity (kWh)	1,151,000	66.15
Petroleum (bbls)	361,000	0.02
Natural gas (cu. ft.)	12,000,000	689.67
Coal and coke (metric tons)	3,375,000	0.19

[a] Based on 17,400,000 metric tons of lime sold and used.

Source: Miller, M.M. 2000b. Minerals Yearbook: Lime–1998. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390498.pdf>. Last updated December 22, 2000.

U.S. Department of Energy, Energy Information Administrations. 1999. 1994 Manufacturing Energy Consumption Survey (MECS): Table A1. <http://www.eia.doe.gov/emeu/mecs/mecs94/consumption/mecs5.html>. Last updated May 26, 1999.

Summing the impacts on energy markets due to projected output reductions and changes in compliance equipment yields the projected changes in energy use provided in Table 4-7 for cost scenarios both with and without PM CEMS. Clearly, the changes in energy consumption expected to occur under this rule fall far below the thresholds for significance under EO 13211 in every case.

Table 4-7. Significant Energy Action Impact Analysis

Energy Sector	Threshold	Change Without CEMS	Significant?	Change With CEMS	Significant?
Crude Oil (barrels per day)	>10,000	–60.4	No	–61.8	No
Fuel (barrels per day)	>4,000	–19.3	No	–19.7	No
Electricity (billion kWh per year)	>1	–0.02	No	–0.02	No
Coal (million metric tons per year)	>5.5	–0.07	No	–0.07	No
Natural Gas (billion cu. ft. per year)	>25	–0.23	No	–0.24	No

Source: Miller, M.M. 2000b. Minerals Yearbook: Lime–1998. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390498.pdf>. Last updated December 22, 2000.

U.S. Department of Energy, Energy Information Administration. 1999. 1994 Manufacturing Energy Consumption Survey (MECS): Table A1. <http://www.eia.doe.gov/emeu/mecs/mecs94/consumption/mecs5.html>. Last updated May 26, 1999.

4.4.2 Assessment

Although the proposed rule leads to declines in energy use, impacts on energy markets are all well below thresholds used to define "significant energy action." Therefore, the Agency concludes that the proposed rule is not a "significant energy action" as defined in EO 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use" (66 Fed. Reg. 28355 [May 22, 2001]).

SECTION 5

SMALL BUSINESS FLEXIBILITY ANALYSIS

Section 112 of the CAA requires the Agency to list categories and subcategories of major sources, and, in some cases, area sources of HAP and to establish national emission standards. Lime manufacturing facilities that are major sources are included on the list of source categories. Lime production leads to emissions of PM, including metals; HCl; and gaseous pollutants, including CO, CO_2, SO_2, and NO_x. The proposed rule is primarily intended to reduce the emissions of PM/metals from lime kilns. These emissions have been demonstrated to cause adverse health effects. Therefore, the objective of the proposed rule is to protect air quality and promote public health by applying MACT standards to all major sources in this source category. The criteria used to establish MACT are contained in section 112 (d) of the CAA.

This regulatory action will potentially affect the economic welfare of owners of lime kilns. These individuals may be owners/operators who directly conduct the business of the firm or, more commonly, investors or stockholders who employ others to conduct the business of the firm on their behalf through privately held or publicly traded corporations. The individuals or agents who manage these facilities have the capacity to conduct business transactions and make business decisions that affect the facility. The legal and financial responsibility for compliance with a regulatory action ultimately rests with plant managers, but the owners must bear the financial consequences of the decisions. Although environmental regulations can affect all businesses, small businesses may have special problems complying with such regulations.

The Regulatory Flexibility Act (RFA) of 1980 requires that special consideration be given to small entities affected by federal regulations. The RFA was amended in 1996 by the Small Business Regulatory Enforcement Fairness Act (SBREFA) to strengthen its analytical and procedural requirements. Under SBREFA, the Agency must perform a regulatory flexibility analysis for rules that will have a significant impact on a substantial number of small entities.

The Agency has prepared this Small Business Flexibility Analysis (SBFA) to examine the impact of the proposed rule on small entities within this source category along with regulatory alternatives that could reduce that impact. As detailed in this section, EPA identified the businesses that this proposed rule will affect and conducted an economic analysis to determine whether this rule is likely to impose a significant impact on a substantial number of the small businesses within this industry. The screening analysis employed here is a "sales test" that computes the annualized compliance costs as a share of sales for each company. In addition, the SBFA provides information about the impacts on small businesses using a market analysis that accounts for behavioral responses to the proposed rule and the resulting changes in market prices and output.

As required by Section 609(b) of the RFA, as amended by SBREFA, the Agency convened a Small Business Advocacy Review (SBAR) panel to obtain advice and recommendations of representatives of the small entities that potentially would be subject to the rule's requirements. Prior to convening the SBAR panel, EPA conducted a sales test for small businesses based on a earlier provisions considered for inclusion in the proposed rule. The results of that analysis indicated much more significant impacts on small entities than the rule as it is currently being proposed. The reduction in impacts is a direct result of the SBAR panel's recommendations incorporated in this proposed rule.

5.1 Identifying Small Businesses

In October 2000, the Small Business Administration (SBA) released guidelines that provide small business definitions based on NAICS codes that replace the previous definitions based on SIC codes. Under these new guidelines, the SBA classifies firms in the lime manufacturing industry (NAICS 32741) as small if they have fewer than 500 employees. For firms that primarily operate in other industries, but produce lime as one of their lines of business (e.g., for captive use), the small business criteria differs. For beet sugar producers and steel mills, the definition of a small business is one with fewer than 750 employees and 1,000 employees, respectively. As described in Section 2, the Agency has identified 19 of the 45 lime companies as small businesses based on these SBA size definitions. These small companies owned and operated 21 lime plants in 1997.

5.2 Screening-Level Analysis

To assess the potential impact of this rule on small businesses, the Agency calculated the share of annual compliance costs relative to baseline sales for each company both with and without a requirement to install PM CEMS. Annual compliance costs include annualized capital costs and operating and maintenance costs imposed on these companies.[1] When a company owns more than one affected facility, EPA combined the costs for each facility owned by that company to generate the numerator of the cost-to-sales ratio. Given the uncertainty of company-specific cost data for large firms, EPA compared the total annual compliance costs for large firms with total sales of large firms (reported in Section 2). This type of analysis does not consider interaction between producers and consumers in a market context. Therefore, it likely overstates the impacts on producers and understates the impacts on consumers because it does not consider potential increases in the price of lime.

5.2.1 Without PM CEMS

Small businesses are expected to incur about 31 percent of the total industry compliance costs of $22.4 million (see Table 5-1). The average total annual compliance cost without PM CEMS controls is projected to be $358,000 per small company. The mean (median) cost-to-sales ratio for the 19 small businesses is 1.6 percent (0.9 percent), with a range of 0 to 8.3 percent. EPA estimates that 9 of the 19 small businesses (47 percent) experience an impact greater than 1 percent of sales. Four firms (21 percent) have costs greater than 3 percent of sales. In contrast, the total annual compliance costs for large firms are approximately 0.01 percent of total company sales.

Similar analysis of earlier provisions under consideration for inclusion in this rule indicated much greater impacts on small businesses than this proposed rule. In draft versions of this rule, the average total annual compliance cost was about $567,000 per small company and the mean (median) cost-to-sales ratio for the 19 small businesses was 2.6 percent (3.0 percent). The Agency estimated that 11 small businesses (58 percent) would experience an impact greater than 1 percent of sales and 10 small businesses (53 percent) would experience impacts greater than 3 percent of sales. The reduction in small business costs between earlier versions of this rule and the proposed rule are attributable to EPA's outreach and accommodation for small firms, which includes the conduct of the SBAR panel.

[1]Annualized capital costs include purchased equipment costs (PEC), direct costs for installation (DCI), and indirect costs for installation (ICI) related to engineering and start up. Operating and maintenance costs include direct annual costs (DAC), such as catalysis replacement, increased utilities, and increased labor, and indirect annual costs (IAC), such as costs due to tax, overhead, insurance, and administrative burdens.

Table 5-1. Summary Statistics for SBREFA Screening Analysis: 1997

	Without PM CEMS		With PM CEMS	
	Small	**Large**	**Small**	**Large**
Total Number of Companies	19	26	19	26
Total Annual Compliance Costs (TACC) ($\$10^6$/yr)	\$6.8	\$15.6	\$7.3	\$16.0
Average TACC per company	\$358,000	\$592,000	\$383,000	\$615,000
Companies with Sales Data	19 (100.0%)	26 (100.0%)	19 (100.0%)	26 (100.0%)
Compliance costs are 0% of company sales	6 (31.6%)	NA	6 (31.6%)	NA
Compliance costs are <1% of company sales	4 (21.1%)	NA	3 (15.8%)	NA
Compliance costs are 1% to 3% of company sales	5 (26.3%)	NA	6 (31.6%)	NA
Compliance costs are 3% of company sales	4 (21.1%)	NA	4 (21.1%)	NA
Compliance Cost-to-Sales Ratios				
Average	1.6%	0.01%	1.8%	0.01%
Median	0.9%	NA	1.1%	NA
Maximum	8.3%	NA	8.8%	NA
Minimum	0.0%	NA	0.0%	NA

NA = not available.
Note: Assumes no market responses (i.e., price and output adjustments) by regulated entities.

5.2.2 With PM CEMS

Under this scenario, small businesses are expected to incur about 31 percent of the total industry compliance costs of \$23.3 million (see Table 5-1). The average total annual compliance cost with PM CEMS controls is projected to be \$383,000 per small company. The mean (median) cost-to-sales ratio for the 19 small businesses is 1.8 percent (1.1 percent), with a range of 0 to 8.8 percent. EPA estimates that 10 of the 19 small businesses (53 percent) experience an impact greater than 1 percent of sales, with four firms (21 percent) having costs greater than 3 percent of sales. In contrast, the total annual compliance costs for large firms are approximately 0.01 percent of total company sales.

As for the regulatory option without a PM CEMS requirement, the impacts on small businesses are much smaller than under draft versions of this proposed rule. In earlier versions, the average total annual compliance cost was about \$592,000 per small company and the mean (median) cost-to-sales ratio for the 19 small businesses was 2.7 percent (3.0 percent). The Agency estimated that 11 small businesses (58 percent) would experience an impact greater than 1 percent of sales and 10 small businesses (53 percent) would experience impacts greater than 3 percent of sales. The reduction in small business costs between earlier versions of this rule and the proposed rule are attributable to EPA's outreach and accommodation for small firms, which includes the conduct of the SBAR panel.

5.3 Economic Analysis

The Agency also analyzed the economic impacts on small businesses under with-regulation conditions expected to result from implementing the NESHAP. Unlike the screening analysis, this approach examines small business impacts in light of the behavioral responses of producers and consumers to the regulation. As shown in Table 5-2, the economic model projects pre-tax earnings to decline by about $1.9 million (22.1 percent) without PM CEMS and $2.2 million (25.5 percent) with the PM CEMS requirement. This is the net result of three effects:

- decreased revenue—revenue declines as output declines. This is offset to some degree by increases in the market price of quicklime (i.e., each ton of lime is sold at a higher market price). However, quantity falls by a larger percentage than price rises for small businesses due to a projected plant closure.
- decreased production costs—total production costs decline as output falls.
- increased pollution control costs—although these costs increase with the rule, the estimated costs after allowing for behavioral adjustments are smaller than those estimated by the engineering cost analysis because these costs are assumed to vary with output. Given that output declines, pollution control costs also decline relative to the costs estimated by the engineering analysis. In addition, two plants are projected to close and avoid paying any compliance costs, reducing total compliance costs compared with those generated under the engineering analysis described in Section 3.

As highlighted in Section 4, 2 of the 14 commercial plants owned by small firms are projected to close under both control cost scenarios.

5.4 Assessment

As a result of the SBAR panel, this rule contains a significant number of accommodations for small businesses. The results presented here confirm that the mitigating measures employed by the Agency have minimized the potential negative impacts of the proposed rule on small businesses while satisfying the objectives of the CAA. The share of

Table 5-2. Small Business Impacts of the Proposed Lime Manufacturing MACT: 1997

		Without PM CEMS		With PM CEMS	
		Change		Change	
	Baseline	Absolute	Relative	Absolute	Relative
Quantity (tons/yr)	2,652,310	–373,110	–14.1%	–378,239	–14.3%
Revenue ($\$10^6$/yr)	\$150.1	–\$18.4	–12.3%	–\$18.7	–12.4%
Costs ($\$10^6$/yr)	\$141.6	–\$16.6	–11.7%	–\$16.5	–11.7%
Control	\$0.0	\$3.4	NA	\$3.7	NA
Production	\$141.6	–\$19.9	–14.1%	–\$20.2	–14.3%
Pre-Tax Earnings ($\$10^6$/yr)	\$8.6	–\$1.9	–22.1%	–\$2.2	–25.5%

NA = Not applicable.

small companies affected at or above the 3 percent level has fallen from 53 percent both with and without PM CEMS to 21 percent without PM CEMS and 21 percent with PM CEMS.

The screening analysis indicates that the average cost-to-sales ratio for small lime companies is approximately 1.7 percent. There are four small firms with cost-to-sales ratios above 3 percent both with and without PM CEMS. The market analysis shows impacts to small businesses are mitigated to some degree after considering price and output changes resulting from behavioral responses of producers and consumers. After allowing for these market adjustments, the economic model predicts a reduction in pre-tax earnings for small businesses of about 22.1 percent for the cost scenario without PM CEMS and 25.5 percent for the scenario with PM CEMS. Based on the *Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations* (*QFR*) from the U.S. Bureau of the Census (U.S. Census Bureau, 1998), pre-tax earnings for all reporting companies within the stone, clay, and glass industry group (of which lime manufacturing is one component) were approximately 7.0 percent of revenue. For smaller firms (defined as those with less than \$25 million in assets), pre-tax earnings were 5.7 percent of revenue. Assuming lime manufacturing has profit rates similar to those reported for the overall industry group, there are two small firms that are expected to experience impacts larger than their estimated baseline pre-tax earnings from lime manufacturing under both cost scenarios and are projected to cease operations as a result of the rule.

We do not anticipate any impacts of the proposed NESHAP on small governments or small nonprofit organizations. We have no evidence that either small governments or nonprofit organizations own or operate sources that will be impacted by the proposed NESHAP.

5.5 Projected Reporting and Recordkeeping Requirements

The projected reporting and recordkeeping requirements for these small businesses include initial notifications, startup notifications, and compliance reports. EPA estimates that 14 existing facilities owned by small businesses will be impacted by these requirements. In addition, EPA projects that three new kilns will be added at impacted facilities in the first three years. The professional skills necessary to complete these reports include the ability to calculate emissions and read and follow report format guidance. Facilities impacted by this proposed rule are generally expected to have personnel with the necessary skills because they would need these skills to comply with other environmental regulations, such as the New Source Performance Standards (NSPS) for lime plants.

These recordkeeping and reporting requirements are specifically authorized by section 114 of the CAA (42 U.S.C. 7414) and are consistent with the General Provisions of 40 CFR part 63. All information submitted to EPA for which a claim of confidentiality is made will be safeguarded according to our policies in 40 CFR part 2.

5.6 Other Federal Rules That May Impact Lime Manufacturing Facilities

The NSPS for Lime Manufacturing Plants (40 CFR Part 60, Subpart HH) and Non-Metallic Minerals Processing Plants (40 CFR Part 60, Subpart OOO) may apply to lime manufacturing plants. In addition, some facilities have been regulated by State air emission regulations as part of the State Implementation Plan. In general, the requirements for the NSPS and the NESHAP are either similar and should not need to be duplicated, or the requirements pertain to different things and could not be combined. However, monitoring requirements differ between the NSPS and NESHAP. The NSPS (subpart HH) calls for opacity monitoring on some types of fabric filters; whereas, the NESHAP calls for bag leak detectors, an issue that was raised during the SBAR panel. In the NESHAP proposal, EPA will be seeking comments on whether or not opacity monitoring should be an allowable alternative to bag leak detectors.

5.7 Alternatives to the Proposed Rule

EPA has incorporated significant alternatives into the proposed rule to minimize the impact on small businesses but still meet the objectives of the CAA.

As required by section 609(b) of the RFA, EPA conducted outreach to small entities and convened a SBAR Panel to review advice and recommendations from representatives of the small entities that potentially would be subject to the proposed rule requirements. EPA staff have communicated with, and provided information to, the National Lime Association (NLA) frequently from time-to-time since the lime NESHAP development project began in 1995. Communication with the NLA has occurred via formal meetings in person, formal teleconferences, informal telephone calls, electronic mail exchanges, and formal correspondence. An outreach meeting with potential small entity representatives was held on December 20, 2001, in Washington, D.C. During this meeting, the planned requirements of the proposed rule were presented and comments were solicited. On February 19, 2002, small entity representatives (SER) provided comments (in the form of a detailed presentation, around which there was extensive discussion) during a face-to-face outreach meeting. Subsequently, the NLA, Huron Lime Company, and Mercer Lime and Stone provided supplemental written comments on March 5, 2002.

In addition to EPA's Small Business Advocacy Chairperson, the Panel consists of the Director of EPA's Emission Standards Division (Office of Air and Radiation), the Administrator of the Office of Information and Regulatory Affairs within the Office of Management and Budget, and the Chief Counsel for Advocacy of the Small Business Administration. The panel considered regulatory flexibility options in response to concerns raised by SER. We have incorporated several alternatives into the proposed rule to minimize the impacts on small business while still meeting the objectives of the Clean Air Act. The following section identifies major panel recommendations and EPA's responses. Detailed discussion of background materials and recommendations are provided in the panel report included in the docket for this proposed rule. The major panel recommendations and EPA's response to each are provided below.

Kiln HCl Standard

SBAR Panel Recommendation: The Panel recommends that the proposed rule should not include the HCl work practice standard initially considered by EPA. This recommendation is based on the results of a risk assessment of HCl emissions from lime kilns conducted by NLA. The study concluded there would be an ample margin of safety with respect to HCl levels in the atmosphere without the work practice standard under consideration for HCl. Section 112(d)(4) of the Clean Air Act allows EPA to forego setting an emission standard for HCl, or to set a standard that is less stringent than the MACT floor, if this is the case. EPA has reviewed the risk assessment report, approves of the methodology, and believes, based on the risk assessment, that there would be an ample margin of safety without the HCl work practice standard.

EPA Response: EPA intends to adopt this recommendation in the proposed rule.

Materials Processing Operations

SBAR Panel Recommendation: The Panel recommends that materials processing operations (MPOs) in limestone quarries and MPOs pertaining to lime kiln dust should not be considered affected sources under the proposed rule.

EPA Response: EPA intends to adopt these recommendations in the proposed rule.

Kiln PM/Metals Standard

SBAR Panel Recommendation: The Panel recommends that the proposed rule include a bubbling provision for the kiln PM emission limit, such that the sum of all kilns' and coolers' PM emissions at a lime plant would be subject to the PM emission limit, rather than each individual kiln and cooler.

EPA Response: EPA intends to adopt these recommendations in the proposed rule.

SBAR Panel Recommendation: The Panel recommends that EPA undertake an analysis of the costs and emissions impacts of replacing scrubbers with dry APCDs and present the results of that analysis in the preamble. The Panel also recommends that EPA consider and request comment on establishing a subcategory for kilns equipped with wet scrubbers because of the potential increase in SO_2 and HCl emissions that may result in complying with the PM standard.

EPA Response: EPA intends to adopt these recommendations in the proposed rule.

Area Source Determinations

SBAR Panel Recommendation: The Panel recommends that the recently-developed American Society of Testing and Materials (ASTM) HCl manual method be allowed as an alternative to the EPA Method 320 test for the measurement of HCl for area source determinations.

EPA Response: EPA intends to adopt these recommendations in the proposed rule.

SBAR Panel Recommendation: The Panel recommends that EPA clarify in the preamble to the proposed rule that it is not specifically requiring sources to test for all HAPs to make a determination of whether the lime plant is a major or area source.

EPA Response: EPA intends to further investigate the potential for sources to emit other HAPs at lime plants, and based on its analysis, EPA will (1) consider allowing the use of a HAP metals emission factor, expressed as a ratio of metals:PM, to allow sources to test for PM and then calculate HAP metals emissions rather than to employ the costly and complex direct test for each HAP metal; and (2) EPA will consider stating in the preamble that sources would not be required to test for organic HAPs in making a major source determination, as lime kilns are not expected to emit significant quantities of organic HAPs.

Monitoring Requirements

SBAR Panel Recommendation: The Panel recommends that EPA consider providing the option of using continuous opacity monitoring systems (COMS) in place of bag leak detectors (BLDs).

EPA response: The proposal preamble and/or associated docket materials will discuss the applicability, advantages, and disadvantages of using COMS and BLDs (such as each method's sensitivity or lack of sensitivity, availability and quality of promulgated or approved specifications and procedures to verify initial performance, potential interferences or other quality assurance problems, inapplicability to certain air pollution control device (APCD) designs or configurations, cost, and precision and accuracy relative to the operating system to be monitored and the standards to be proposed); request comment on whether and how opacity could be used as a limit or an operating parameter, and what would be an appropriate MACT floor opacity limit for COMS; and request data on the foregoing issues.

SBAR Panel Recommendation: The Panel recommends that EPA consider and request comment on using a COMS to monitor compliance with an opacity limit (a surrogate for HAP metals emissions). The Panel also recommends that EPA discuss in the preamble that it is considering a range of opacity levels between 10 and 15 percent as the MACT floor opacity limit.

EPA Response: EPA believes that COMS have limited sensitivity at opacities below 10 percent and that the relevant range of opacities for the aforementioned application would be below 10 percent. If COMS were allowed under the rule, EPA would prefer to set an opacity limit because of the COMS' ability to directly measure opacity.

SBAR Panel Recommendation: The Panel recommends that EPA request comments on whether the rule should specify separate, longer averaging time periods (or greater frequencies of occurrence) for demonstrating compliance with parameter limits, or other alternative approaches for demonstrating compliance with operating parameter limits.

EPA Response: EPA intends to adopt this recommendation in the proposed rule.

SBAR Panel Recommendation: The Panel recommends that the incorporation by reference of Chapters 3 and 5 of the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation Manual be removed from the rule.

EPA Response: EPA intends to adopt this recommendation in the proposed rule.

SBAR Panel Recommendation: The Panel recommends that EPA request comments about the suitability of other PM control device operating parameters that can be monitored to demonstrate compliance with the PM emission limits, in lieu of or in addition to the parameters currently required in the draft rule

EPA Response: EPA intends to adopt this recommendation in the proposed rule.

Economic Impacts Analysis

SBAR Panel Recommendation: The Panel recommends that EPA reevaluate the assumptions used in modeling the economic impacts of the standard, taking into consideration the inputs provided by the NLA and other SER.

EPA Response: EPA will conduct a sensitivity analysis using alternative demand and supply elasticities with respect to price based on industry comments to provide a broader picture of the potential impact of this regulation on the lime industry (see Appendix B of this report).

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APPENDIX A

OVERVIEW OF ECONOMIC MODEL DATA, EQUATIONS, AND SOLUTION ALGORITHM

The primary purpose of the EIA for the proposed lime manufacturing NESHAP is to "describe and quantify" the reallocation of society's resources in response to the regulatory action. To develop estimates of the economic impacts on society resulting from the proposed regulation, the Agency used a basic framework that is consistent with economic analyses performed for other rules. This approach employs standard microeconomic concepts to model behavioral responses expected to occur with regulation. This appendix describes the spreadsheet model in detail and discusses how the Agency

- collected the baseline data set for the model,
- characterized the supply and demand of a single lime commodity,
- introduced a policy "shock" into the model by using control cost-induced shifts in the supply functions of affected commercial lime producers, and
- used a solution algorithm to determine a new with-regulation equilibrium for the commercial lime market.

A.1 Baseline Data Set

EPA collected the following market information to characterize the baseline year, 1997:

- *Market quantities*—Domestic production and import and export quantities for quicklime were collected from the USGS (Miller, 2000b, 2000c). To compute an accurate value for total domestic production of quicklime, the Agency adjusted the hydrated lime tonnages reported by USGS by eliminating the weight of water.[1] After this adjustment, the Agency estimated the tonnage of quicklime exchanged in the market by applying the ratio of lime sold to total lime production reported by the USGS for 1997 (17,300/19,700 = 0.88, or 88 percent).[2] The remaining 12 percent of lime is produced not for commercial sale but for captive use as part of a larger production process. Table A-1 reports the quantities used in the market model.

Market price—The Agency used the average price of quicklime for 1997 ($56.60 per metric ton) reported by the USGS (Miller, 2000a).

Supply and demand elasticities—Table A-2 shows the primary supply and demand elasticities used in the model. In the absence of available empirical estimates, the domestic supply elasticity was assumed to be 1. Empirical estimates for other elasticities are available for similar commodities (i.e., Portland cement) or aggregate commodity groups such as stone, clay, and glass, of which lime is one component. EPA used the domestic demand elasticity of –0.9 and foreign supply elasticity of 7.0 reported in the analysis of air pollution regulations of the Portland cement industry (EPA, 1999a). Ho and Jorgenson (1998) report an export demand elasticity of –1.2 for the stone, clay, and glass industry, which was used in this analysis for the lime export demand elasticity. Because of the uncertainty in defining the elasticities, EPA also conducted a sensitivity analysis where the supply and demand elasticities were varied from these primary values to examine the effect on the estimated impacts (see Appendix B).

A.2 Market for Quicklime

A.2.1 Market Supply

Market supply for quicklime can be expressed as

$$Q^S = q_L^S + \sum_{j=1}^{n} q_j^S + q_F^S \tag{A.1}$$

[1]Hydrated lime is made by adding water to quicklime. Hydration does not involve a kiln, and this process is not directly covered by the proposed lime manufacturing MACT rule. However, the quicklime necessary to make hydrated lime is subject to the rule. To generate estimates of the amount of quicklime needed to make the reported quantities of hydrated lime, high calcium hydrate tonnages were multiplied by 0.73, and dolomatic hydrate tonnages were multiplied by 0.70 based on information from Michael Miller, the USGS lime specialist (Miller, 2000d).

[2]No information is available on the percentage of quicklime produced for commercial use, so the fraction of all lime sold commercially was used. The proportion of quicklime produced for commercial sale may not be exactly the same as for all lime, but it is expected to be reasonably close.

Table A-1. Baseline Data Set, 1997

Market	Average Price ($/metric ton)[a]	Domestic Production (10^3 metric tons)[b]	Imports (10^3 metric tons)[c]	Exports (10^3 metric tons)[c]
Quicklime	$56.60	16,751	186	52

[a] Miller, M. 2000c. Minerals Yearbook: Lime–1999. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390499.pdf>. Last updated December 22, 2000.

[b] Miller, M. 2000c. Minerals Yearbook: Lime–1999. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390499.pdf>. Last updated December 22, 2000.
Miller, M. 2000d. December 21, 2000. Personal communication with Robert Beach, Research Triangle Institute. Total quicklime production.

[c] Miller, M. 2000b. Minerals Yearbook: Lime–1998. <http://minerals.usgs.gov/minerals/pubs/commodity/lime/390498.pdf>. Last updated December 22, 2000.

Table A-2. Supply and Demand Elasticities for Quicklime Used in the Market Model

Market	Supply	Demand
Domestic	1.0[a]	–0.9[b]
Foreign	7.0[b]	–1.2[c]

[a] Assumed value.

[b] U.S. Environmental Protection Agency (EPA). 1999a. *Economic Analysis of Air Pollution Regulations: Portland Cement*. Research Triangle Park, NC: U.S. Environmental Protection Agency.

[c] Ho, M., and Jorgenson, D. 1998. "Modeling Trade Policies and U.S. Growth: Some Methodological Issues." Presented at USITC Conference on Evaluating APEC Trade Liberalization: Tariff and Nontariff Barriers. September 11-12, 1997. <http://www.usitc.gov/wais/reports/arc/w3101.htm>.

where

q_L^S = commercial quicklime supply from plants owned by large plants,

q_j^S = commercial quicklime supply from small plant j,

n = the number of small commercial plants producing quicklime (n=14),

q_F^S = quicklime supply from foreign sources (imports).

DRAFT

A.2.1.1 Domestic Supply From Large Firms

EPA used a Cobb Douglas (CD) supply function for a single representative supplier to represent the total supply from large firms. This function is expressed as follows:

$$q_L{}^S = A \bullet (P - c_L)^{\varepsilon^S_{dom}} \tag{A.2}$$

where

$q_L{}^S$ = the supply of quicklime from large firms,

A = a parameter that calibrates the supply equation to replicate estimated production,

P = the average market price for quicklime,

$^S_{dom}$ = the domestic supply elasticity, and

c_L = the per-unit control costs for large firms.

All large firms were modeled together as a single representative supplier because insufficient data were available to assign plant-level costs to plants owned by these firms. Thus, predictions concerning individual large firms are likely to be inaccurate, while an aggregate supplier representing all large firms should more accurately predict the overall response of the large firms in the market[3]

A.2.1.2 Domestic Supply From Small Firms

EPA also used a CD supply function for each commercial plant owned by small firms:

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[3]Plants either receive costs or do not receive costs for each individual cost category, but averaging across multiple simulations yields expected cost for each plant, which will not equal their actual costs. For example, if a firm has a 70 percent chance of being a major source, the simulations would generate expected costs for that firm base on this proportion. However, in actuality, each individual large firm either would receive only nominal costs if they are an area source or would receive the full costs if they are a major source. Although it is not possible to predict the actual costs for an individual plant, the average total cost across the simulations should be reasonably close to the actual total costs that would be experienced by large plants.

$$q_j^S = B \bullet (P - c_j)^{\varepsilon^S_{dom}} \qquad (A.3)$$

where

q_j^S = the supply of quicklime from plant j,

A = a parameter that calibrates the supply equation to replicate the estimated production for each plant,

P = the average market price for quicklime,

$^{S}_{dom}$ = the domestic supply elasticity, and

c_j = the per-unit control costs for small plant j.

Regulatory Induced Shifts in the Supply Function (c). The upward shift in the supply function is calculated by taking the annual compliance cost estimate and dividing it by baseline output. Computing the supply shift in this manner treats the compliance costs as the conceptual equivalent of a unit-tax on output. Typically, the Agency assumes that only the operating cost component of compliance costs varies with output levels. In that case, the costs that vary with output are the only compliance costs that affect the firm's decision regarding how much to produce, and the supply curve is assumed to shift up by the average variable per-unit operating cost. The fixed cost component of compliance costs is assumed to only influence the facility's decision regarding whether to operate or to exit the market. However, an argument can be made that, prior to investing in compliance capital, the scale of these expenditures could, at least in principle, vary with the level of output. Thus, the Agency determined that including annual capital costs as part of the supply shift was appropriate for this analysis.

Plant and Kiln Closure Analysis. One of the most sensitive issues to consider in the EIA is the possibility that the regulation may induce a producer to shut down operations rather than comply with the regulation. The data (i.e., direct observations of plant-level costs and profits) necessary to make definitive projections of these impacts are unavailable from the survey data. Therefore, the Agency developed a method of identifying firm closure decisions using industry measures of profitability. The plant closure criterion used for this analysis is:

[redacted] $TAFPC_j \quad TVCC_j \quad 0 \text{ then } q_j^S \quad 0$ (A.4)

where total revenue (TR_j) is the product revenue from plant j, and total cost (TC_j) is the sum of the plants total variable production costs ($TVPC_j$= area under the supply function), total avoidable fixed production costs ($TAFPC_j$ [computed below]), total avoidable fixed compliance costs ($TAFCC_j$), and total variable compliance costs ($TVCC_j$). The conceptually correct view would assume the plant also has some positive liquidation value or opportunity value[4] in an alternative use that is not captured in the TC elements above. However, no data are available to estimate these opportunity costs. Therefore, the Agency has assumed they are exactly offset by the costs of closing a kiln (i.e., equal to zero).

The U.S. Bureau of Census reports industry group financial ratios in their *Quarterly Financial Report for Manufacturing, Mining and Trade Corporations* (U.S. Census Bureau, 1998). For 1997, the Census Bureau reports that income before income taxes (pre-tax earnings) for SIC groups 32 and 33 was approximately 7.0 percent of revenue. For smaller firms (i.e., firms with assets under $25 million) this ratio is 5.7 percent. Given the estimated 1997 values of revenue and variable production costs, EPA developed an estimate of the total avoidable fixed production costs so that the pre-tax profit rate for each supply sector exactly matches the rate reported by the Bureau of the Census.

A.2.1.2 Foreign Supply (Imports)

Foreign producers do not face additional costs of production with regulation. However, their output decisions are only affected indirectly by price changes expected to result from the regulation. Foreign supply is expressed as follows:

$$q_F^S = C \cdot P^{\epsilon_F^S} \tag{A.5}$$

where

q_F^S = the level of imports,

C = a parameter that calibrates the supply equation to replicate quicklime imports,

[4]Note this value could also be negative if costs are associated with liquidation that can be avoided by continuing to operate a kiln.

P = the average market price for quicklime, and

η_F^S = the foreign supply elasticity.

A.2.2 Market Demand

Market demand for lime can be expressed as the sum of domestic and foreign demand, that is,

$$Q^D = q_{dom}^D + q_F^D \tag{A.6}$$

where q_{dom}^D is the domestic demand and q_F^D is the foreign demand (or exports).

A.2.2.1 Domestic Demand

Domestic demand was expressed as follows:

$$q_{dom}^D = D \bullet P^{\eta_{dom}^D} \tag{A.7}$$

where

q_{dom}^D = domestic demand for quicklime,

D = a parameter that calibrates the demand equation to replicate domestic demand,

P = the average market price for quicklime, and

η_{dom}^D = the domestic demand elasticity.

A.2.2.2 Foreign Demand (Exports)

Domestic demand was expressed as follows:

$$q_F^D = E \bullet P^{\eta_F^D} \tag{A.8}$$

where

q_F^D = foreign demand (exports) for lime,

E = a parameter that calibrates the demand equation to replicate quicklime exports,

P = the average market price for quicklime, and

η_F^D = the foreign demand elasticity.

A.3 With Regulation Market Equilibrium Solution Algorithm

Producer responses and market adjustments can be conceptualized as an interactive feedback process. Plants facing increased production costs due to compliance are willing to supply smaller quantities at the baseline price. This reduction in market supply leads to an increase in the market price that all producers and consumers face, which leads to further responses by producers and consumers and thus new market prices, and so on. The new with-regulation equilibrium is the result of a series of iterations in which price is adjusted and producers and consumers respond, until a set of stable market prices arises where total market supply equals market demand (i.e., $Qs = Q_D$). Market price adjustment takes place based on a price revision rule that adjusts price upward (downward) by a given percentage in response to excess demand (excess supply).

The algorithm for determining with-regulation equilibria can be summarized by 9 recursive steps:

1. Impose compliance costs.
2. Use supply functions to derive marginal responses given the base price.
3. Check if TR>TC (i.e., Eq. A.4) for small plants; if not set q_j=0.
4. Compare aggregate supply and demand.
5. Revise prices using the Walrasian auctioneer approach.
6. Use supply functions to derive marginal responses given the revised price.
7. Check if TR>TC (i.e., Eq. A.4) for small plants; if not set q_j=0.
8. Compare aggregate supply and demand.

9. Go to Step #5 and continue until convergence is obtained (i.e., the difference between supply and demand is arbitrarily small).

APPENDIX B

SENSITIVITY ANALYSIS

As noted in Section 4, no empirical estimates of supply or demand elasticities for lime were identified in the economics literature. As a result, the Agency used the following approaches to select the primary values used for these parameters in the economic model:

- Supply elasticity—a value of 1.0 was used under the assumption that suppliers would be willing to change the quantity of lime they are willing to supply to the market by the same proportion that price changes for the relevant range of output. This value has often been used by the Agency as a reasonable approximation of supply response in cases where empirical estimates of the relevant supply elasticities were not available.
- Demand elasticity—the best point estimates available for elasticities of similar products (e.g., Portland cement) were used.

Although EPA believes these parameter values are reasonable given the currently available data and information, the Agency conducted a sensitivity analysis using alternative parameter values to determine the robustness of the results. This appendix outlines the approach used for the sensitivity analysis and reports the results of this analysis.

The choice of elasticity values is important because the ultimate distribution of costs across producers and consumers depends on the *relative supply and demand elasticities* selected for the analysis. As consumers become *more (less)* responsive to marginal changes in price relative to producers, they will bear *less (more)* of the regulatory burden. Similarly, as producers become *more (less)* responsive to marginal changes in price relative to consumers, they will bear *less (more)* of the regulatory burden. We can see why these changes occur by examining the results of very simple mathematical model of tax incidence:[1]

$$\frac{dp^{D}}{dc} = \frac{\varepsilon^{S}}{\varepsilon^{S} - \eta^{D}} \qquad \text{(B.1a)}$$

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[1]Derivation of this result can be found in intermediate microeconomic textbooks such as Nicholson (1998).

$$-\frac{\frac{dp^S}{dc}}{\frac{dp^D}{dc}} = -\frac{\eta^D}{\varepsilon^S} \qquad \text{(B.1c)}$$

$$\frac{dp^S}{dc} = \frac{\eta^D}{\varepsilon^{S_i} - \eta^D} \qquad \text{(B.1b)}$$

where

dp^D = change in price paid by consumers

dp^S = change in price received by suppliers

dc = per-unit control costs

^{s} = market elasticity of supply

^{d} = market elasticity of demand

Equations B.1a and B.1b generate the share of the costs being borne by consumers and producers, respectively. B.1c shows that the ratio of supplier cost share to consumer cost share is equal to the inverse of the ratio of their respective elasticities. For example, the values selected for this analysis suggest supply is slightly more elastic than demand, which implies consumers will bear more of the costs than producers. Assuming no plant closures[2], consumers would be projected to bear slightly more than half the total social costs associated with the rule (Using equation B.1a: -1/(1-(-0.9))=0.52, or 52 percent).

For the sensitivity analysis, we considered the following two general cases and report the elasticity assumptions for each scenario in Table B-1:

- supply is significantly more responsive than demand, e.g., if there were sufficient overcapacity at current production levels to cause very large supply responses while demanders of lime were much less responsive to price changes than demanders of Portland cement. In this case, suppliers can more

[2]Although somewhat counterintuitive, when there are facility closures, the share of social costs borne by producers actually tends to decline. The facilities that close often are estimated to have fairly small baseline pre-tax earnings and, depending on the elasticities used, removing their output from the market may lead to projected increases in price large enough that gains to their competitors more than offset the reduction in pre-tax earnings for the firms that close.

easily pass on compliance costs to their customers relative to the baseline case presented in Section 4. In scenario A1, it was assumed that supply was twice as elastic and demand was half as elastic as in the baseline scenario, whereas in scenario A2, it was assumed that supply was five times as elastic and demand was one fifth as elastic. These values were chosen to show a range of impacts as conditions become more favorable to producers attempting to pass on compliance costs.

- demand is significantly more responsive than supply, e.g., if purchasers of lime are much more price sensitive than purchasers of Portland cement and lime suppliers have only limited ability to change the quantity they supply in response to price changes. In this case, it is much harder for producers to pass compliance costs on to their customers than in the baseline scenario. In scenario B1, it was assumed that supply was half as elastic and demand was twice as elastic as in the baseline scenarios, whereas in scenario B2, it was assumed that supply was one fifth as elastic and demand was five times as elastic. These values were chosen to show a range of impacts as conditions become less favorable to producers.

As shown in Table B-2, the model projects a fairly broad range of price changes (0.5 percent to 2.1 percent both with and without PM CEMS) and quantity changes (–0.3 percent to –2.3 percent both with and without PM CEMS) across the scenarios analyzed. These differences in market outcomes lead to differences in revenues and earnings of lime facilities (see Table B-3), with pre-tax earnings changes ranging from 3.4 percent to –22.0 percent without PM CEMS and –3.1 percent to –23.4 percent with PM CEMS. The projected number of plant closures ranges from one to two plants. Table B-4 presents the estimated distribution of social costs between various categories of producers and consumers. The total social costs of the rule remain almost constant across the five scenarios presented, but the distribution varies widely. As expected, scenarios A1 and A2, the case where demand is less elastic than supply, consumers bear a high share of the cost burden (about 90 percent of total social cost). Scenarios B1 and B2, where demand is more elastic than supply, the burden to producers is high (about 75.5 percent of total social cost).

Table B-1. Supply and Demand Elasticities for Quicklime Used in the Market Model: Sensitivity Analysis

Scenario/Agent	Supply	Demand
A1		
Domestic	2	–0.45
Foreign	14	–0.60
A2		
Domestic	5	–0.18
Foreign	35	–0.24
B1		
Domestic	0.5	–1.8
Foreign	3.5	–2.4
B2		
Domestic	0.2	–4.5
Foreign	1.4	–6.0

Table B-2. National Market-Level Impacts of the Proposed Lime Manufacturing NESHAP: Sensitivity Analysis

[redacted]

[redacted]

Table B-4. Distribution of Social Costs Associated with the Proposed Lime Manufacturing MACT ($\$10^6$/yr): Sensitivity Analysis

	Base	A1	A2	B1	B2
Without PM CEMS					
Change in Consumer Surplus	–\$19.7	–\$21.9	–\$18.2	–\$12.7	–\$5.1
Domestic	–\$19.5	–\$21.7	–\$17.9	–\$12.5	–\$5.0
Foreign	–\$0.2	–\$0.3	–\$0.3	–\$0.1	–\$0.1
Change in Producer Surplus	–\$0.6	\$1.6	–\$2.0	–\$7.5	–\$15.0
Domestic					
Commercial	\$0.0	\$2.2	–\$1.4	–\$6.8	–\$14.2
Large	\$1.9	\$3.8	\$0.6	–\$3.9	–\$10.3
Small	–\$1.9	–\$1.6	–\$2.0	–\$2.9	–\$3.9
Captive	–\$0.8	–\$0.8	–\$0.8	–\$0.8	–\$0.8
Foreign	\$0.2	\$0.3	\$0.3	\$0.1	\$0.1
Total Social Cost	–\$20.2	–\$20.3	–\$20.2	–\$20.1	–\$20.1
With PM CEMS					
Change in Consumer Surplus	–\$20.1	–\$22.6	–\$19.0	–\$12.9	–\$5.1
Domestic	–\$19.9	–\$22.3	–\$18.7	–\$12.7	–\$5.1
Foreign	–\$0.2	–\$0.3	–\$0.3	–\$0.1	–\$0.1
Change in Producer Surplus	–\$1.0	\$1.4	–\$2.1	–\$8.2	–\$15.9
Domestic					
Commercial	–\$0.4	\$2.0	–\$1.5	–\$7.5	–\$15.0
Large	\$1.8	\$3.8	\$0.7	–\$4.3	–\$10.8
Small	–\$2.2	–\$1.8	–\$2.3	–\$3.2	–\$4.2
Captive	–\$0.9	–\$0.9	–\$0.9	–\$0.9	–\$0.9
Foreign	\$0.2	\$0.3	\$0.3	\$0.1	\$0.1
Total Social Cost	–\$21.2	–\$21.2	–\$21.1	–\$21.1	–\$21.0